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BACTERIOLOGICAL SURVEYS OF LAKE SUPERIOR NEARSHORE AND EMBAYMENTS, 1973 AND 1974



Ministry
of the
Environment

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BACTERIOLOGICAL SURVEY OF THE CANADIAN NEARSHORE
AREA OF LAKE SUPERIOR, 1973.

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MICROBIOLOGY SECTION
LABORATORY SERVICES BRANCH
ONTARIO MINISTRY OF THE ENVIRONMENT

JULY 1978.

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ABSTRACT

In order to assess the water quality of the Canadian shoreline of Lake Superior, monitoring surveys of selected representative stations were conducted throughout the summer and fall of 1973. The overall bacterial water quality was excellent, with the only exception being in the vicinity of communities in which pulp and paper mills were located.

INTRODUCTION

The nearshore monitoring was conducted in order to establish a baseline assessment of the prevailing microbiological water quality. This baseline could then be used as a standard against which the effects of future shoreline development on the microbiological water quality of the lake could be measured. The shoreline of the lake is largely undeveloped, with isolated urban communities scattered along Hwy. 17. The pulp and paper industry is the heart of most towns along the shoreline, including Thunder Bay, Red Rock, and Terrace Bay. Very little cottage development has taken place along the lake, with the exception of the Batchawana and Whitefish Bay regions.

METHODS:

A. Field Procedures:

The area surveyed contained 67 stations running along the Lake Superior shore from Whitefish Bay to Thunder Bay. In addition, five ranges were established at selected points, with each range being comprised of four stations extending perpendicularly from the shoreline into the lake for a distance of eight kilometres. (Fig. 1).

Surface and depth samples were collected at each station in sterile 237 ml rubber air syringes. The surface samples were collected 1.0 metres below the surface of the lake, while the depth samples were collected at varying depths up to 40 metres. The samples were stored on ice until they were delivered to the mobile laboratory for analysis.

When received, the samples were aseptically transferred to sterile 250 ml polycarbonate bottles and were analysed within 24 hrs of sampling using membrane filtration techniques.

The shoreline stations were monitored over three different time periods, June-July, August-September and September-October.

B. Laboratory Methods:

- see Laboratory Methods section of Thunder Bay report (1).

C. Statistical Methods:

Due to the sparsity of samples from each area, surface and depth sample results were combined to give two results per station per sampling run. For a complete description of the statistical methods employed, see the Statistical Methods section of the Thunder Bay Report. (1)

RESULTS

A circumspection of the data reveals that the vast extent of Lake Superior shoreline is of exceedingly good microbial quality. Elevated coliform concentrations were only found off-shore from urban centres which, in nearly all cases, were areas with pulp and paper mills. Indicative of the excellent water quality in areas free of industrial development were the results from an intensive survey of the area from Gros Cap to Corbeil Pt., carried out in June. Eleven stations were sampled on each of four runs within six days. 83% of the samples analyzed were coliform free, and the highest coliform concentration detected was 4/100 ml. Only 2 of 86 samples were positive for fecal coliforms. In the June-July survey, elevated coliform levels were found in Thunder Bay Harbour, Pine Bay, and Black Bay (Fig. 2). In the August-September

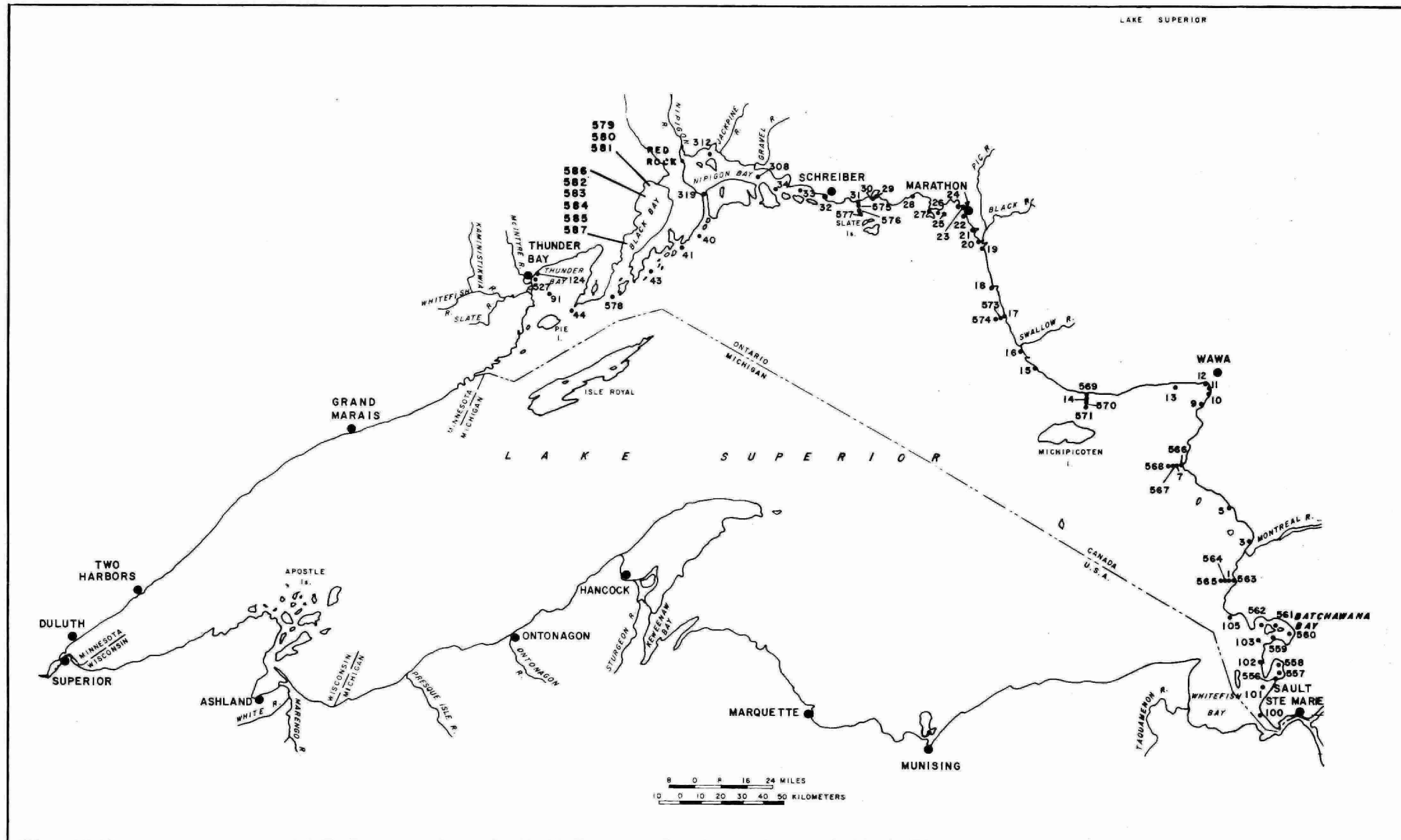


FIG.1 LAKE SUPERIOR NEARSHORE SURVEY AREA.

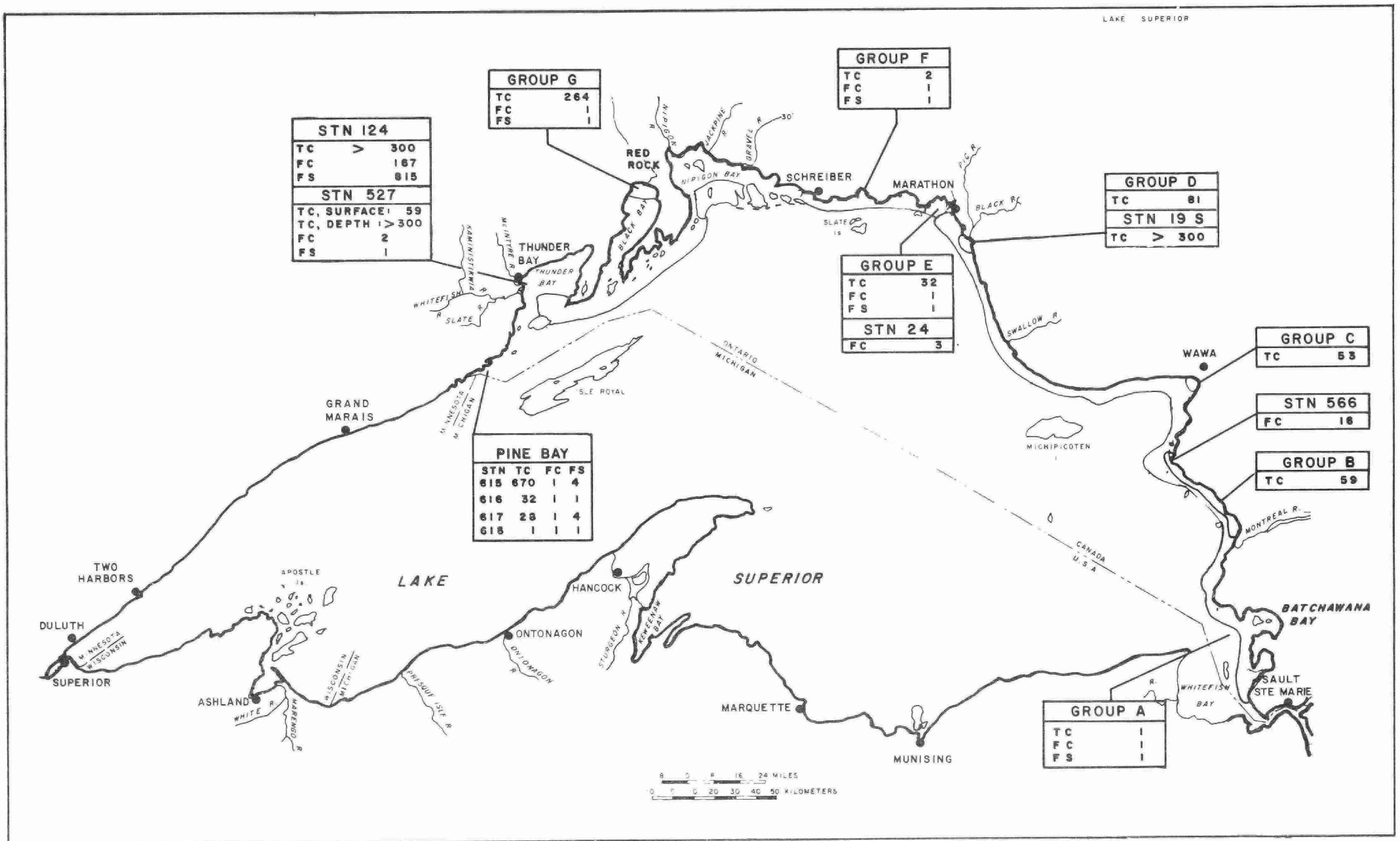


FIG. 2 LAKE SUPERIOR BACTERIOLOGICAL LEVELS DURING JUNE-JULY 1973.

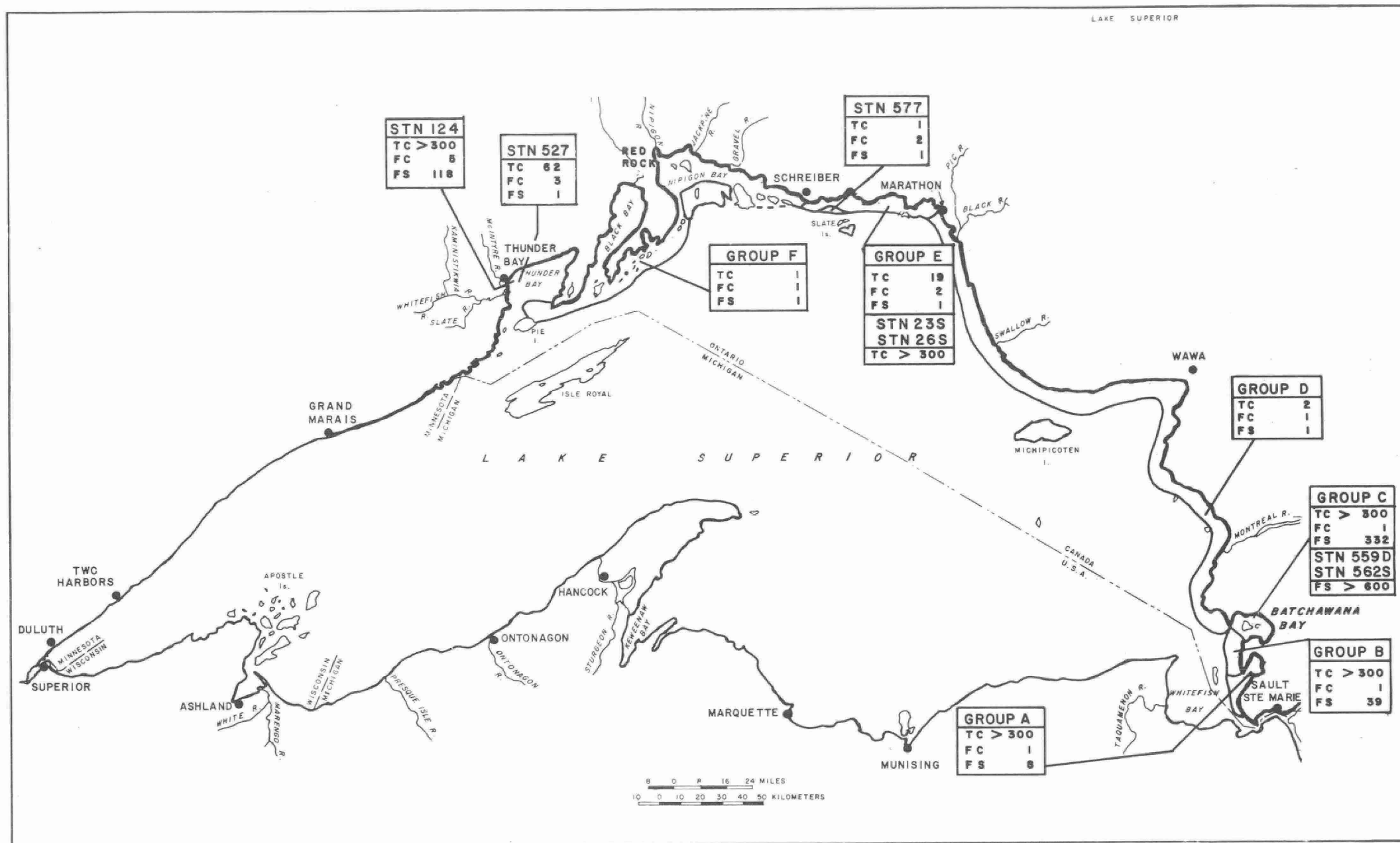


FIG 3 LAKE SUPERIOR BACTERIOLOGICAL LEVELS DURING AUGUST-SEPT., 1973.

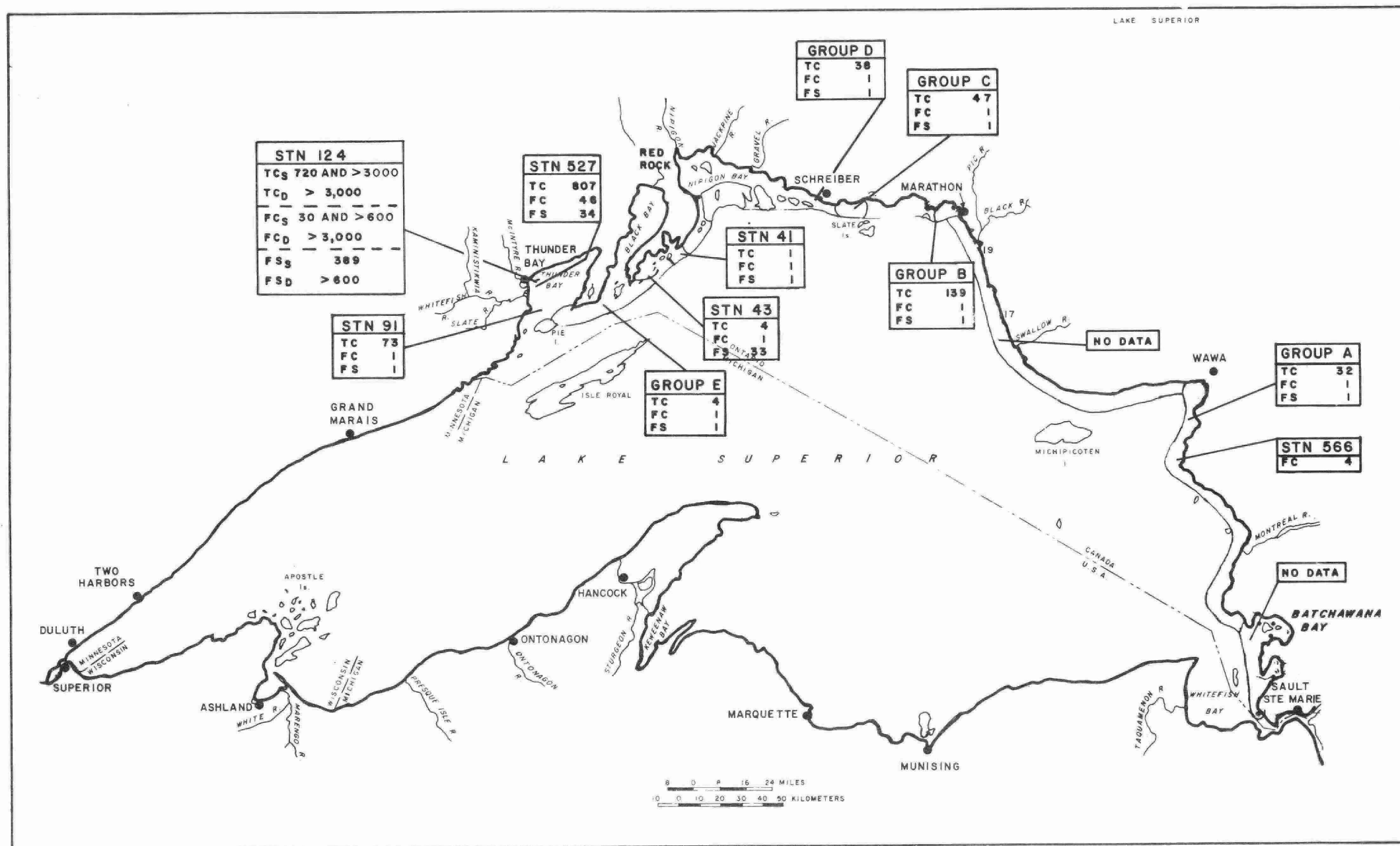


FIG. 4 LAKE SUPERIOR BACTERIOLOGICAL LEVELS DURING SEPT-OCTOBER, 1973.

survey, elevated coliform levels were found in Thunder Bay harbour and in the Batchewana and Whitefish Bay areas near Sault Ste Marie (Fig.3). Thunder Bay Harbour was the only region where greatly elevated coliform levels were evident during the Sept.-October survey. (Fig. 4).

The heterotrophic bacterial count in all regions was <200/ml with the exception of Thunder Bay harbour where >10,000/100 ml were detected. Later experimental evidence indicated the methodology used to determine the heterotrophic bacterial level was inhibitory to the bacteria. Consequently, the heterotrophic bacterial count is underestimated.

DISCUSSION AND CONCLUSIONS:

The near shore area of Lake Superior is of excellent microbiological quality. Total and fecal coliform bacteria were rarely detected, except in the vicinity of urban development and pulp and paper mills. The Thunder Bay region was consistently the most degraded section of the surveyed area. This is due to the large amount of industrial and municipal waste discharged into the bay.

Elevated coliform levels were detected in the Batchewana Bay-Whitefish Bay region during the August-September survey. These elevated levels may be due to the recreational and cottage use in this area.

Recommendations:

1. Present criteria used for bathing beaches have established the FC/FS ratio as a useful tool in defining waste sources. This ratio cannot be used properly on near shore data unless the sampling procedure is changed and stations are located nearer to shore. Consequently, it is recommended that the FS parameter

be dropped from near-shore monitoring surveys, except at source stations.

2. The fecal coliform parameter similarly is not of sufficient sensitivity or use to warrant its use in near-shore monitoring surveys. Its use in Lake Superior may be limited to the region between Marathon and Thunder Bay where sources of fecal pollution were indicated.

3. In order to properly detect and evaluate pollution sources between Marathon and Thunder Bay, the three day repeat monitoring type of survey, as is used on the lower Great Lakes, should be implemented in this region.

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BACTERIOLOGICAL WATER QUALITY OF
THUNDER BAY IN 1973 AND 1974.

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FEBRUARY 1978.

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THUNDER BAY 1973 AND 1974 BACTERIOLOGICAL WATER
QUALITY REPORT

Abstract:

Surveys of Thunder Bay harbour were conducted in 1973 and 1974 to determine whether pollution abatement programmes in the area had resulted in improved water quality since the previous intensive survey of the area in (1970). The results demonstrated that distinct improvements in the microbial water quality of Thunder Bay harbour had taken place. However, the Thunder Bay Inner Harbour was still one of the most bacteriologically polluted regions of the Ontario nearshore area of Lake Superior.

Introduction and Background

Thunder Bay is the most heavily populated area along the Canadian shore of Lake Superior. An effect of this extensive urbanization and industrialization has been the severe impairment of the Kaministiquia River and Thunder Bay Harbour, due to the municipal and industrial wastes that have been introduced into the water system. Great concern has been expressed over this contamination of the lake water as future expansion and growth of the region would be limited by poor water quality.

In 1970 a complete intensive water quality survey of the Thunder Bay region was conducted by the Ontario Ministry of the Environment (MOE)(1). The entire Thunder Bay Inner Harbour and lower Kaministiquia River exceeded the limits for recreational waters as set down in "Guidelines and Criteria for Water Quality Management in Ontario", which sets geometric mean (G.M) limits of 1000 total coliforms (T.C.), 100 fecal coliforms (F.C.), and 20 fecal streptococci (F.S.) per 100 ml.(2). At that time the main sources of pollution were investigated and identified as to their location and type.

The Thunder Bay region was subdivided into three distinct zones: Zone 1 - The Kaministiquia River Basin, which extends 10 miles inland from Thunder Bay.

Zone 2 - Thunder Bay Inner Harbour, which is bounded by the harbour breakwall on the east, and reaches from Bare Point in the north to a point opposite the Kaministiquia River.

Zone 3 - Thunder Bay Outer Harbour, which includes the portion of Thunder Bay adjacent to the Inner Harbour, and extending north from Whiskey Jack Point to the Bare

point pumping station and as far offshore as the Welcome Islands.

There were five major sources of pollution in the Kaministiquia River Basin. The largest and most extensive industrial pollution source was the Great Lakes Paper Co. Ltd. Other industrial polluters included Industrial Grain Products Ltd., and Dow Chemical of Canada Ltd. The Thunder Bay South Sewage Treatment Plant discharges its chlorinated effluent into the Kaministiquia River and was a major source of phosphorus and nitrogen in this area. In addition to these, there were numerous outfalls discharging untreated sanitary wastes directly into the river. These outfalls were the main sources of bacterial pollution in Zone 1, and are of public health concern.

The main industrial polluters in the Thunder Bay Inner Harbour (Zone 2) were the Abitibi Forest Products Ltd., The Canada Malting Co. Ltd., and The Northern Wood Preservers Ltd. The major source of bacterial pollution was the Clarke St. Combined Sewer, which discharged untreated municipal waste into the harbour.

The major industrial sources of pollution in the Thunder Bay Outer Harbour (Zone 3) were Abitibi Forest Products Ltd., Thunder Bay Division, and Abitibi Paper Co. Ltd., Fort William Division. The major bacterial pollution sources were the Lillian Street Combined Sewer and, of course, the Kaministiquia River.

Two bacteriological surveys were carried out in the Thunder Bay area (Fig.1) in 1973. The first, conducted in August was an intensive survey covering 7 stations in the Inner Harbour,

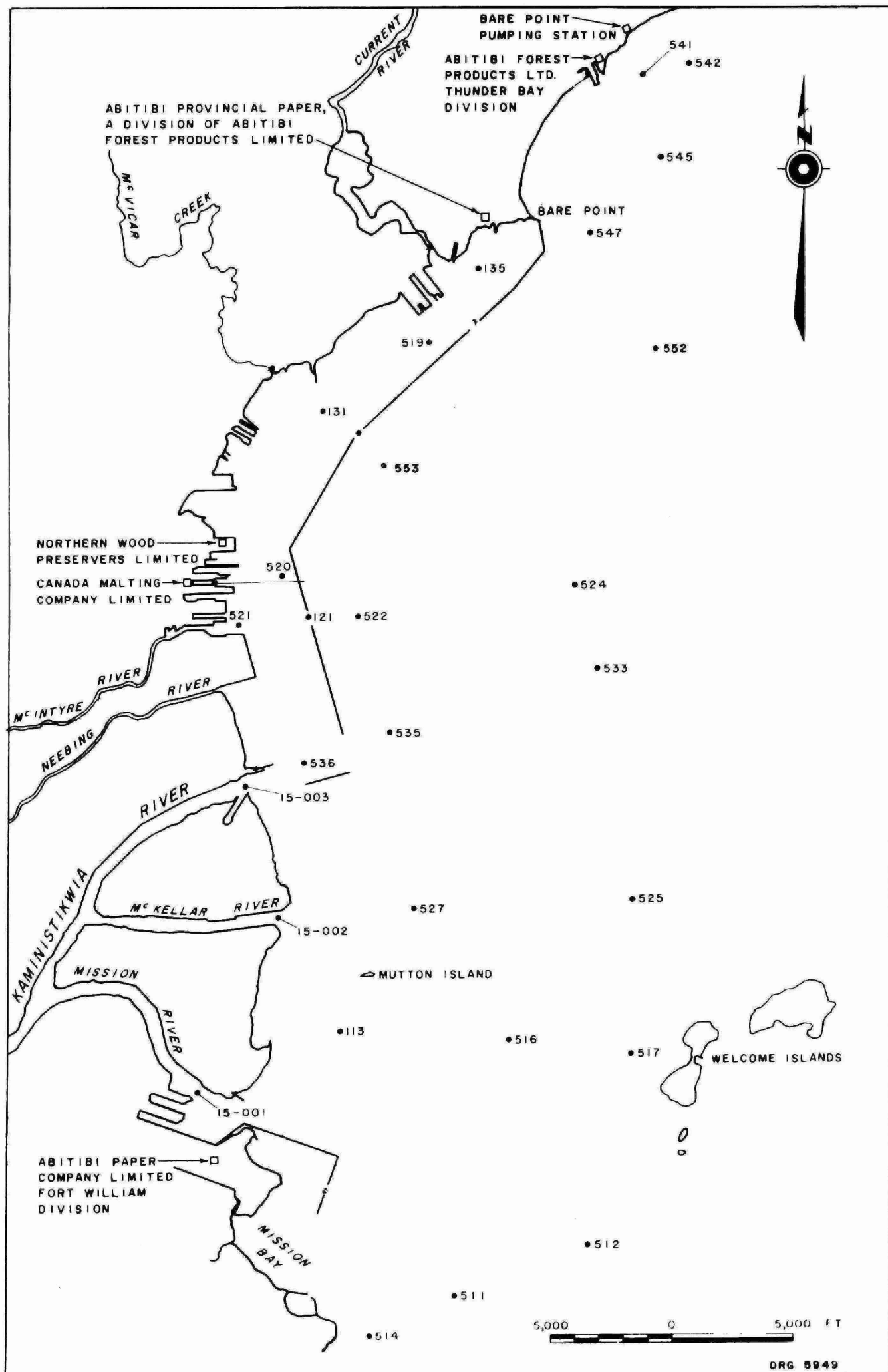


FIG.1 THUNDER BAY SAMPLING POINTS, 1973.

18 in the Outer Harbour, and 3 stations at the south of the Kaministikwia, McKellar, and Mission Rivers. The second survey in October covered the same stations but due to surveying problems, only two runs could be made instead of the planned intensive survey.

In 1974, three day bacteriological surveys were conducted in June and October (Fig.2) to extend the data collected in 1973. The 1974 survey area was smaller than the 1973 area, with more emphasis being placed on discharges emanating from the Kaministikwia River Area.

Methods:

A) Physical: In 1973, the samples were collected using a modified "piggy-back" sampler and sterile 237 ml. evacuated rubber syringes. Samples were stored on ice immediately after sampling. When they arrived at the mobile laboratory they were transferred aseptically to sterilized 250 ml. polycarbonate bottles and analyzed within 12 hours of sampling. In 1974, all samples were collected in 6 oz. sterile glass bottles. Analyses for total coliforms (T.C.), fecal coliforms (F.C.) and fecal streptococci (F.S.) using the membrane filtration technique (M.F.) as described in Standard Methods (13th edition) (3) were performed using m-Endo agar Les (Difco) for T.C. and MacConkey membrane broth (Oxoid) along with an incubation period of 18 hours for F.C. determinations.

In 1974 two additional parameters were utilized. A spot plate technique was used to determine the heterotrophic count (H.B.) (4) and *Pseudomonas* (P.aer.) densities were determined using a membrane filtration technique on mPA medium (5).

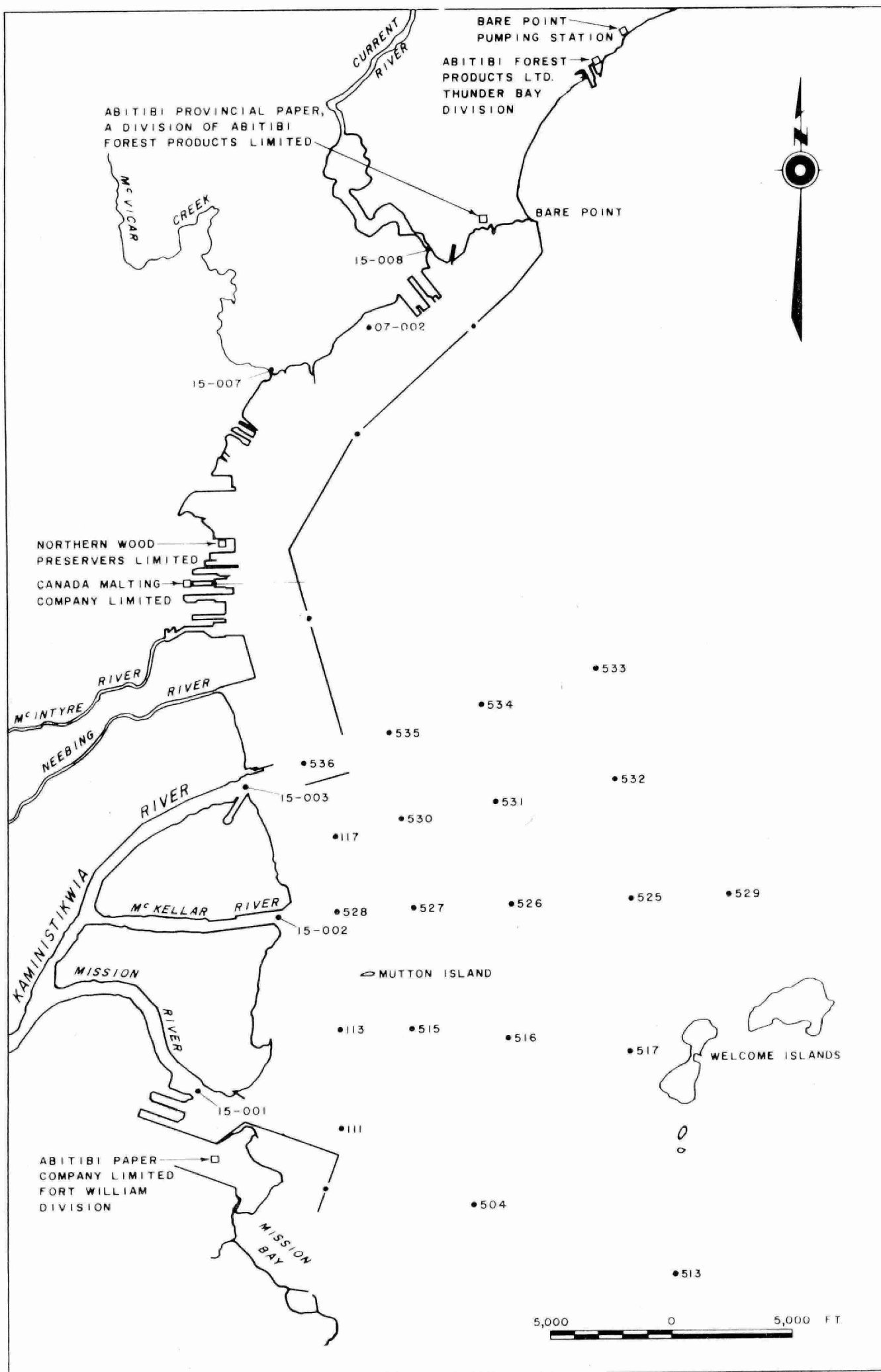


FIG.2 THUNDER BAY SAMPLING POINTS, 1974

B) Statistical: Water quality cannot be assessed accurately from a single sample because of changing environmental conditions. Therefore a large number of samples were taken to satisfy these conditions. Statistical methods were used to summarize the results concisely and to reduce biased interpretation of the data. An analysis of variance programme (ANOVA) was used to summarize the data. In this programme the calculated F ratio must be less than the critical F ratio (0.05 level) in order that sections comprise a statistically similar group. If the F was significant, then those stations with significantly different geometric means (G.M.) were deleted from the overall group to yield a group with similar means. Stations comprised a group, provided that they were not separated by any geographic barrier, that the variances of all the stations were similar (Bartlett's Test of Homogeneity) and that the data were normally distributed. Using the ANOVA programme again, calculations were done on the deleted stations. This process was repeated until all possible groups were formed. The Student-t test (using log G.M. and S.E.) was used to compare overlapping homogeneous areas from the different surveys.

All surveys, except the October 1973 survey, were analyzed statistically. The data obtained from the October 1973 survey was insufficient for statistical analysis.

Results

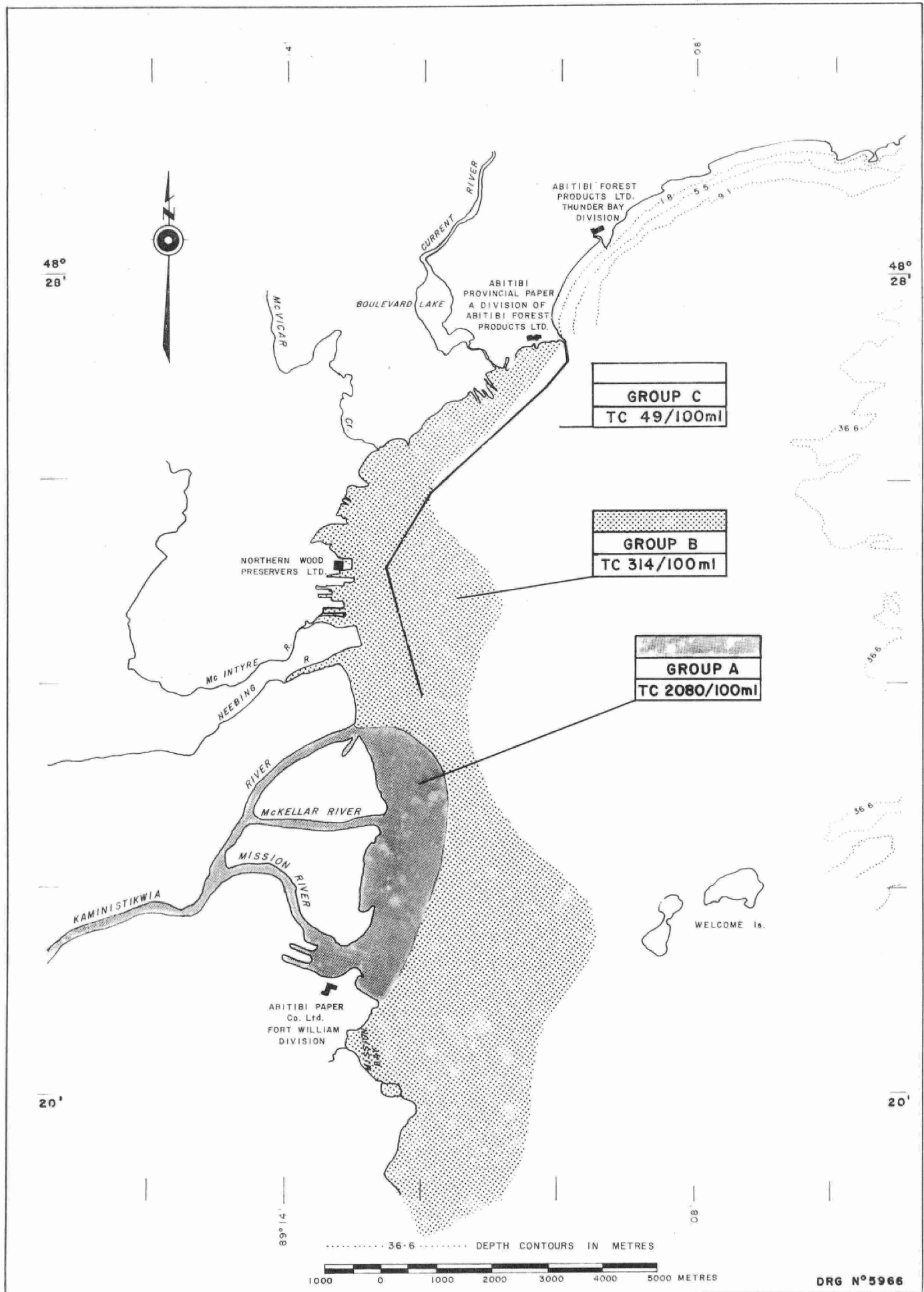
Both the 1973 and 1974 surveys revealed the Thunder Bay harbour region to be the largest heavily polluted region in the lake. The most heavily polluted area is located at the mouths of the Kaministiquia, McKellar and Mission Rivers.

The current water quality criteria for bathing areas has set upper geometric mean (G.M.) limits of 1000 T.C./100 ml. and 100 F.C./100 ml.(6).

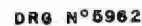
In August 1973, the areas at the mouths of these rivers (Group A) had geometric mean levels of greater than 2000 T.C., 19 F.C. and 35 F.S./100 ml.(MAPS 1 & 2). During the June 1974 survey (MAPS 3 & 4), this area had levels of 1890 T.C. 297 F.C. and 66 F.S./100 ml. while the October 1974 survey had a higher T.C. level of 3400/100 ml. (MAP 5)and FC and FS levels had decreased to 40 and 64/100 ml respectively (MAP 6). Although these levels, at times, exceeded the MOE recreational use criteria, the Kaministiquia River Basin (Zone 1) has improved considerably since the August 1970 survey. At that time (1970), the area had T.C., F.C., and F.S. densities of 8000 T.C., greater than 500 F.C. and greater than 1000 F.S./100 ml. respectively.

The lower levels found in zone 1 in the 1973 and 1974 surveys are indicative of the effectiveness of abatement in this area. Both the Great Lakes Paper Co.Ltd. and Industrial Grain Products Ltd. have improved their waste treatment systems extensively and the number of municipal outfalls that emptied directly into the Kaministiquia River without any treatment have been reduced.

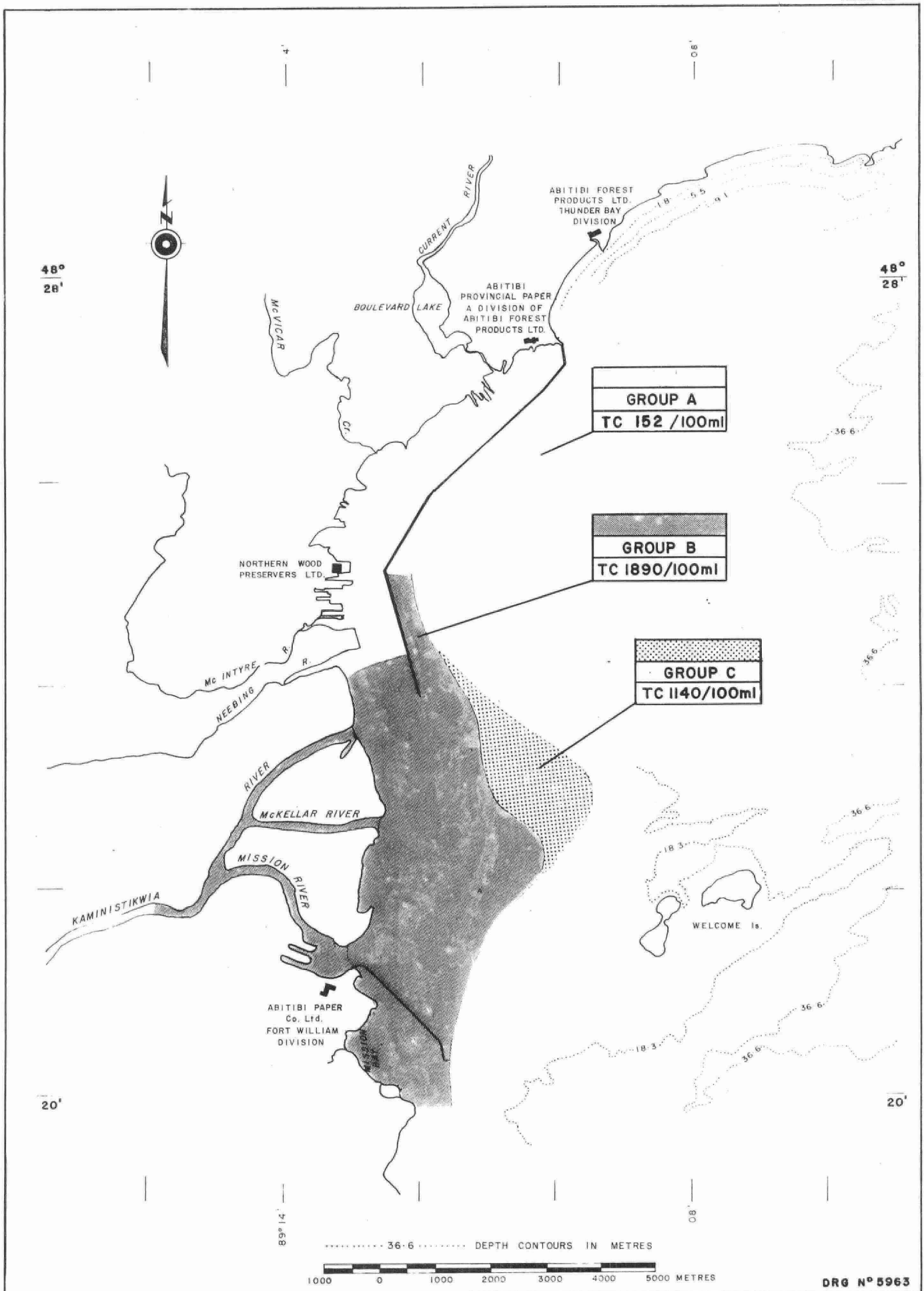
The pollution level in the Thunder Bay Inner Harbour (zone 2) has also lessened considerably since the elimination of the Clark St. combined sewer which has, since the 1970 survey, been connected directly to the municipal interceptor sewer. New facilities for treating wastes were also put into operation by the Abitibi Provincial Paper Division of Abitibi Forests Ltd.



MAP I TOTAL COLIFORM, THUNDER BAY, AUG 2-13, 1973.

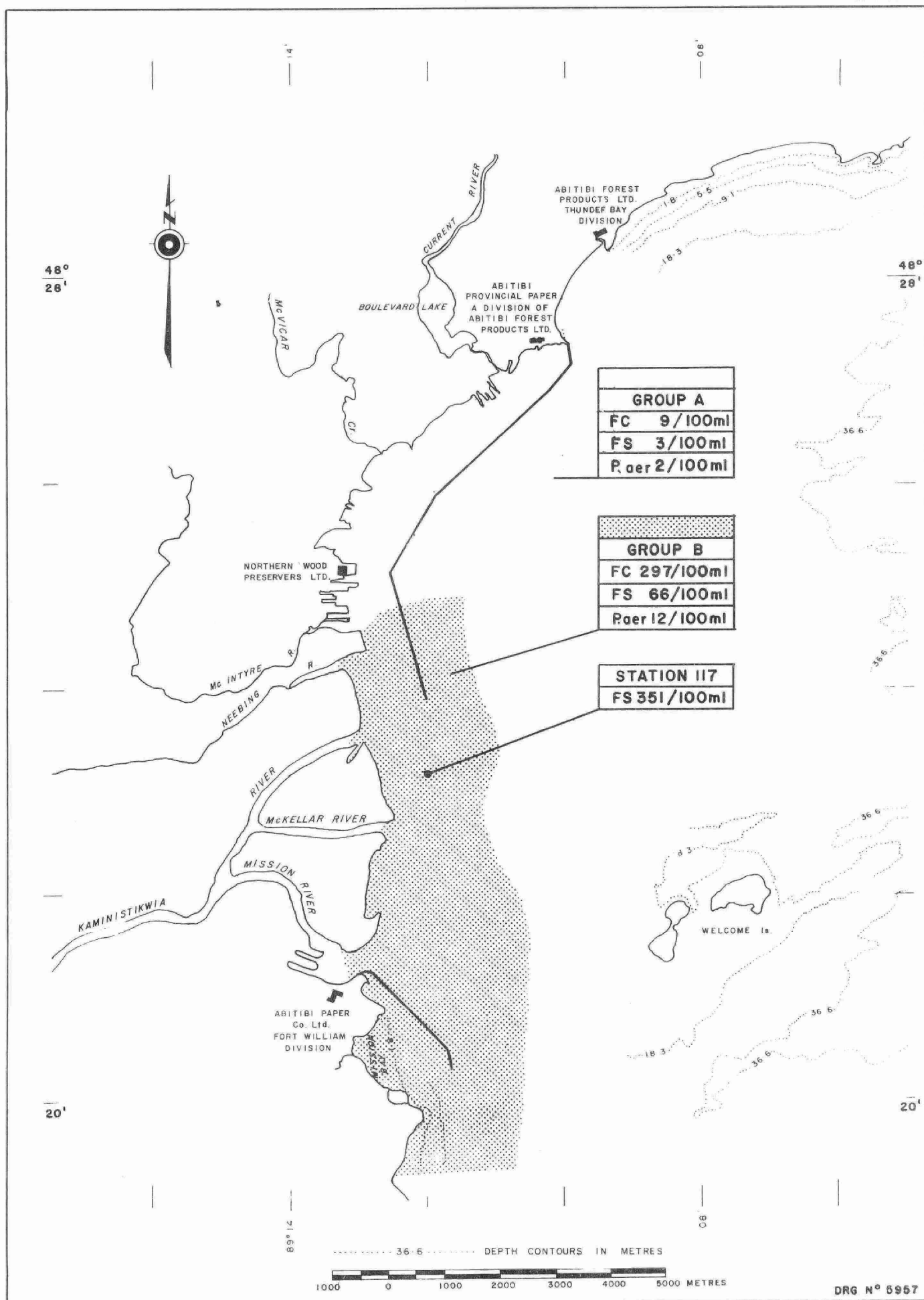


MAP 2 FECAL COLIFORM & FECAL STREPTOCOCCUS, THUNDER BAY,
AUG. 2-13, 1973.

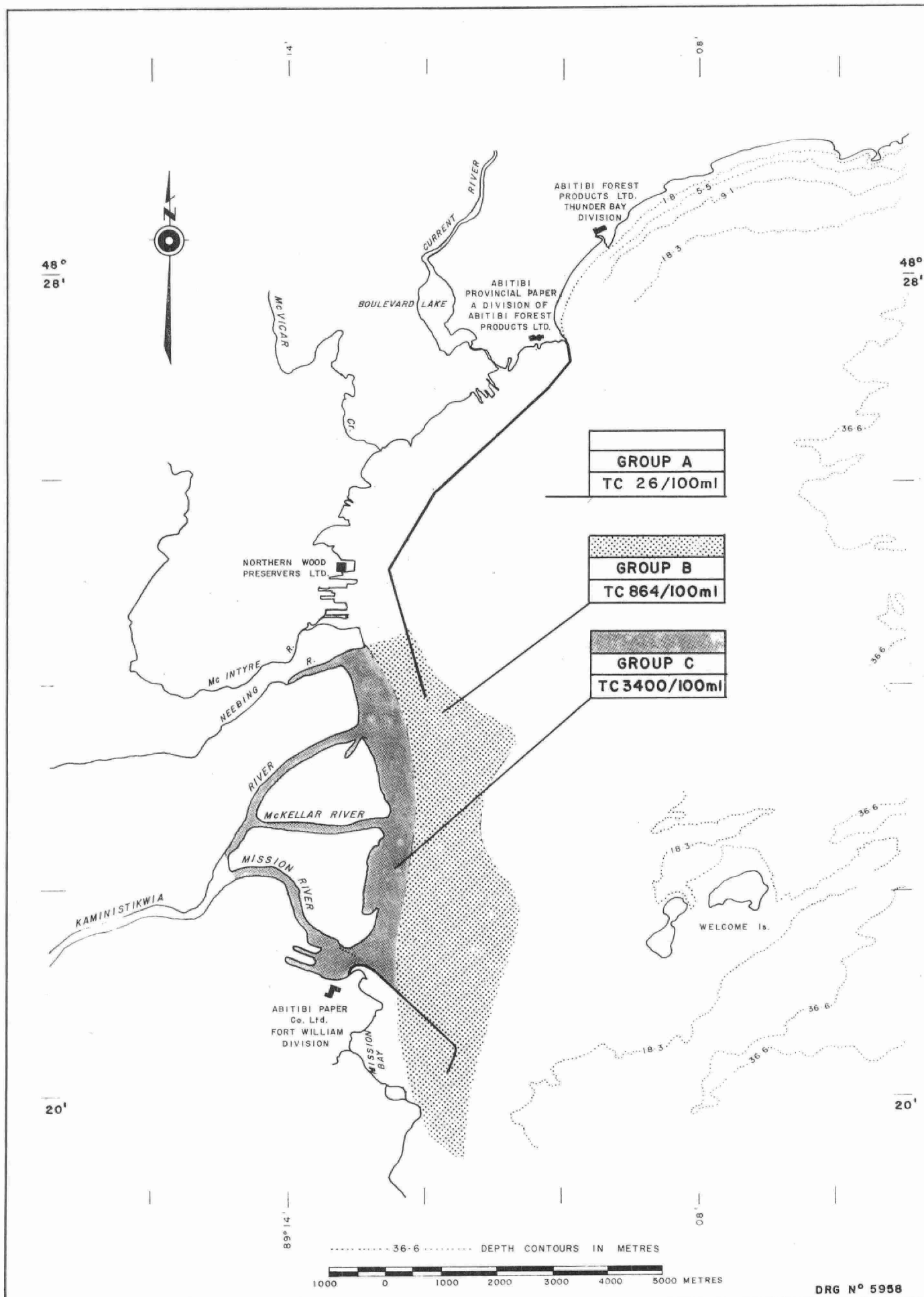


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MAP 3 TOTAL COLIFORMS, THUNDER BAY, JUNE 24-26, 1974.

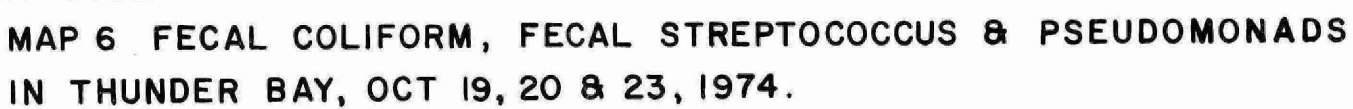


MAP 4 FECAL COLIFORM, FECAL STREPTOCOCCUS, AND PSEUDOMONADS IN THUNDER BAY, JUNE 24-26, 1974.



DRG N° 5958

MAP 5 TOTAL COLIFORM, THUNDER BAY, OCT 19, 20, & 23, 1974.



Zone 3, Thunder Bay Outer Harbour, displayed considerably lower bacterial levels than the Inner Harbour and Kaministiquia River areas for all surveys. T.C., F.C., and F.S. levels in zone 3 were well below the MOE recreational use criteria (Fig.2).

Pseudomonad levels during the 1974 surveys were considerably higher towards the Kaministiquia River area (12 P.aer/100 ml. for both June and October surveys) than the Thunder Bay outer harbour (2 P.aer/100 ml. for both June and October surveys) MAPS(4 & 6). The presence of P. aer is indicative of recent fecal material inputs.

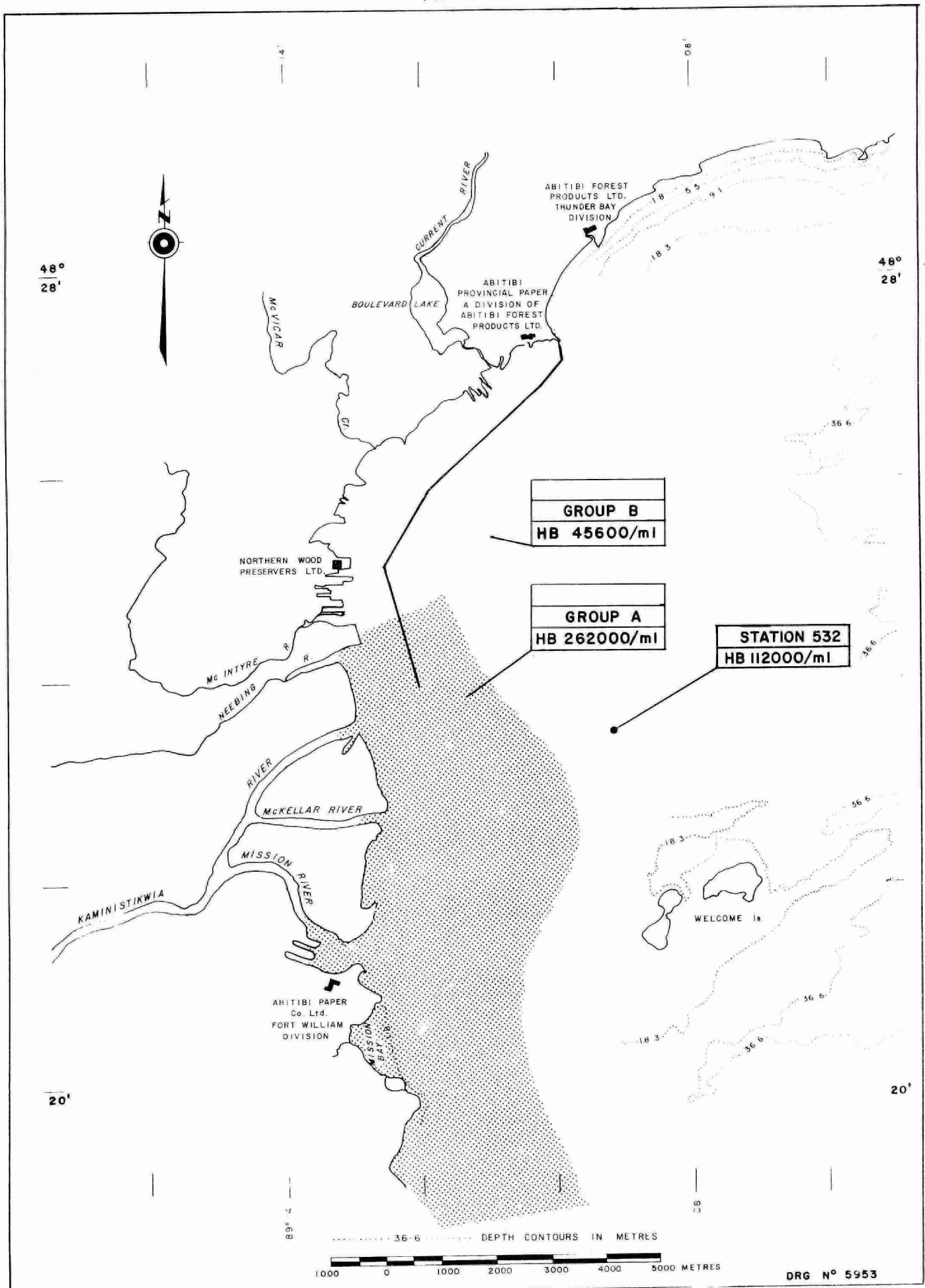
In June H.B. concentration in the Inner Harbour area was 262000/ml while the Outer Harbour had lower levels of 45600/ml (MAP 7); in October H.B. levels were 160,000/ml. in the Inner Harbour and 8090/ml in the Outer Harbour (MAP 8). The H.B. concentrations found in this area indicate much higher nutrient concentrations in the water than found elsewhere along the shoreline.

Comparison of 1973 and 1974 Thunder Bay Surveys

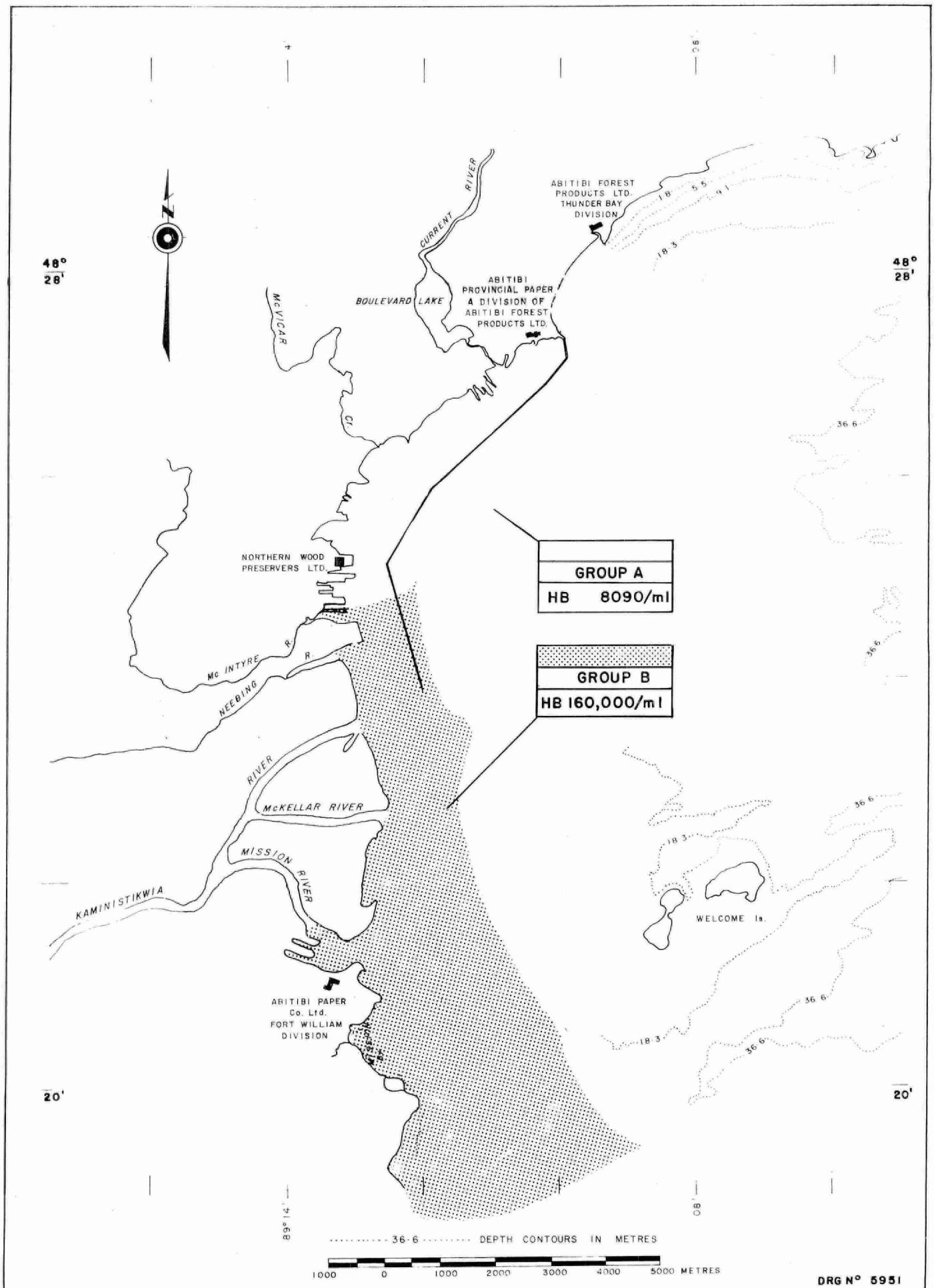
Two surveys were done in 1973 and two in 1974. However, the insufficiency of results per station for the October 1973 survey invalidated any statistical comparisons to the 1974 surveys. Hence only the August 1973 survey will be compared to the June and October 1974 surveys. Pseudomonad and heterotrophic bacterial parameters were not done in 1973.

August 1973 versus June 1974

The area around the river mouths had similar T.C. densities while Thunder Bay Outer Harbour had a threefold increase from 1973 to 1974.



MAP 7 HETEROTROPHIC BACTERIA, THUNDER BAY, JUNE 24-26, 1974.



MAP 8 HETEROTROPHIC BACTERIA, THUNDER BAY, OCT.19,20,&23, 1974

The entire survey area had F.C. densities that rose markedly in 1974 over 1973.

The survey area also had F.S. concentrations that rose, but non-significantly in 1974 over 1973.

August 1973 versus October 1974

Towards the river mouths T.C. densities rose from 1973 to 1974 except the north western area of the Welcome Islands where levels decreased in 1974.

A similar pattern was apparent for the F.C. and F.S. parameters.

Summary

Bacterial concentrations displayed similar distribution patterns during the 1973 and 1974 surveys with higher levels at the mouths of the rivers and lower levels towards the Outer Harbour area.

The 1974 surveys generally indicated higher bacterial levels than in 1973 and levels frequently exceeded recreational use guideline. Levels from both these years, however, indicated that the Kaministiquia River Basin (zone 1) had improved considerably since the August 1970 survey. Nevertheless, relative to other near shore Lake Superior stations, the Thunder Bay Inner Harbour is greatly polluted and further abatement measures appear necessary to improve the deteriorated water quality.

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BACTERIOLOGICAL WATER QUALITY
OF NIPIGON BAY IN 1973 AND 1974

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FEBRUARY 1978

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Abstract

Samples taken and analyzed for bacterial parameters from the Domtar Plume in October 1973 and in July and August 1974 indicated that the pulp and paper mill plume greatly exceeded the Ministry of the Environment (MOE) bacteriological public surface water supplies criteria (1). This plume, a vast reservoir of bacteria, could prove very deleterious to the aquatic environment in Nipigon Bay.

Introduction

In 1973, a preliminary study of the Red Rock area of Nipigon Bay (Figure 1) was conducted to estimate types and amounts of bacteria being introduced into Nipigon Bay through pulp and paper mill effluents and sanitary waste discharges.

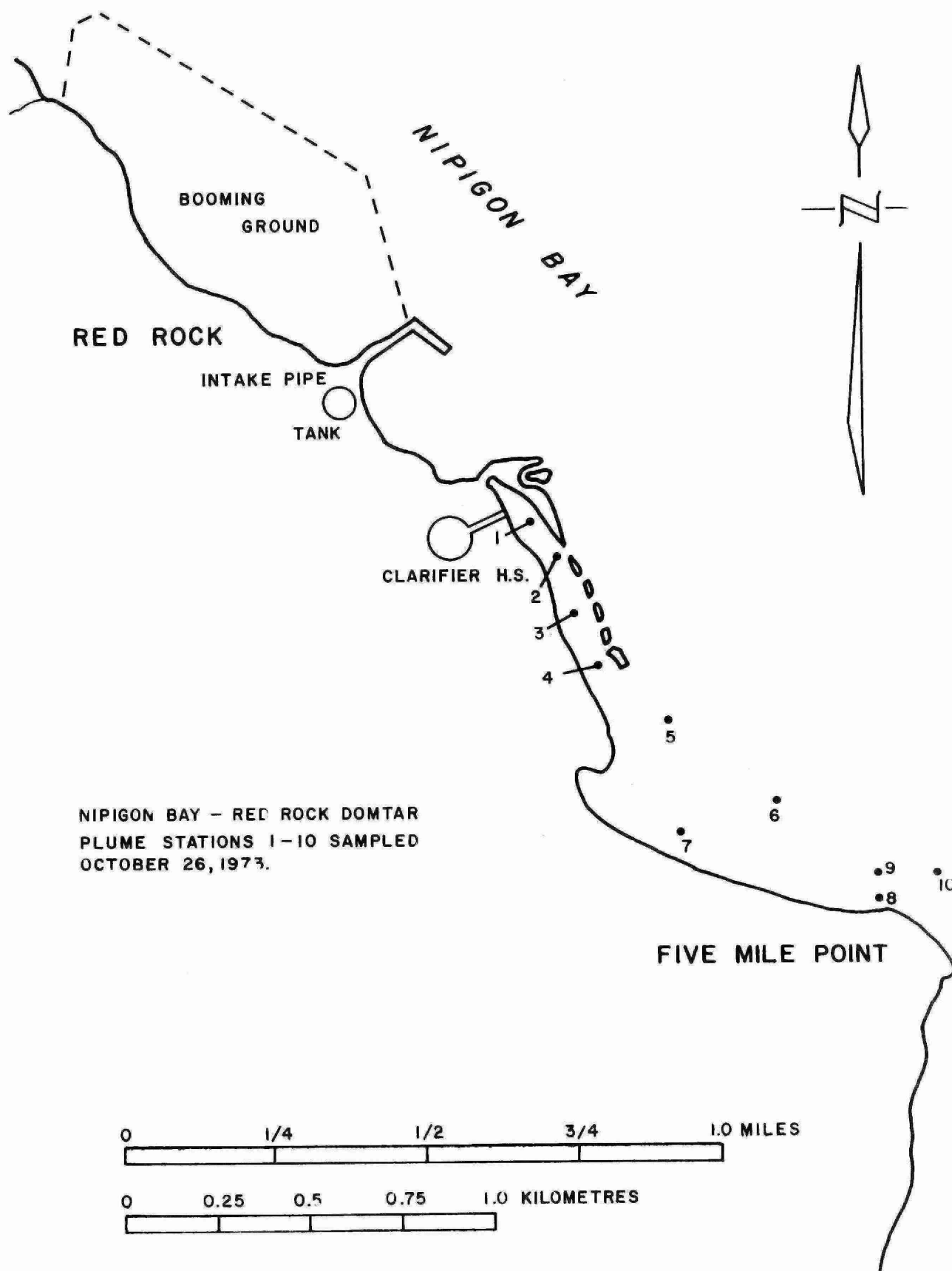
In 1974, a more intensive survey of the area was done (Figure 2) to extend the data collected in 1973 and to determine the biotic impact of a pulp and paper mill discharge to Nipigon Bay, and to define the zones of effect under variable climatic and waste loading conditions for the purpose of developing waste treatment guidelines (2).

Methods

a) Physical:

In 1973, samples were collected by means of sterile 237 ml evacuated rubber syringes. Samples were stored on ice until they arrived at the mobile laboratory within 12 hours of sampling, at which time they were transferred aseptically to sterilized 250 ml polycarbonate bottles. In 1974, all samples were collected in 175 ml sterile glass bottles. Analysis for total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) using the membrane filtration technique (MF) as described in Standard Methods (3) were performed using m-Endo agar LES (Difco) for TC and MacConkey membrane broth (Oxoid), along with an incubation period of 18 hours, for FC determinations.

In 1974, a spot plate technique was used to determine heterotrophic bacterial (HB) levels.



DRG. N° 8091

FIGURE 1 NIPIGON BAY SAMPLING POINTS, 1973.

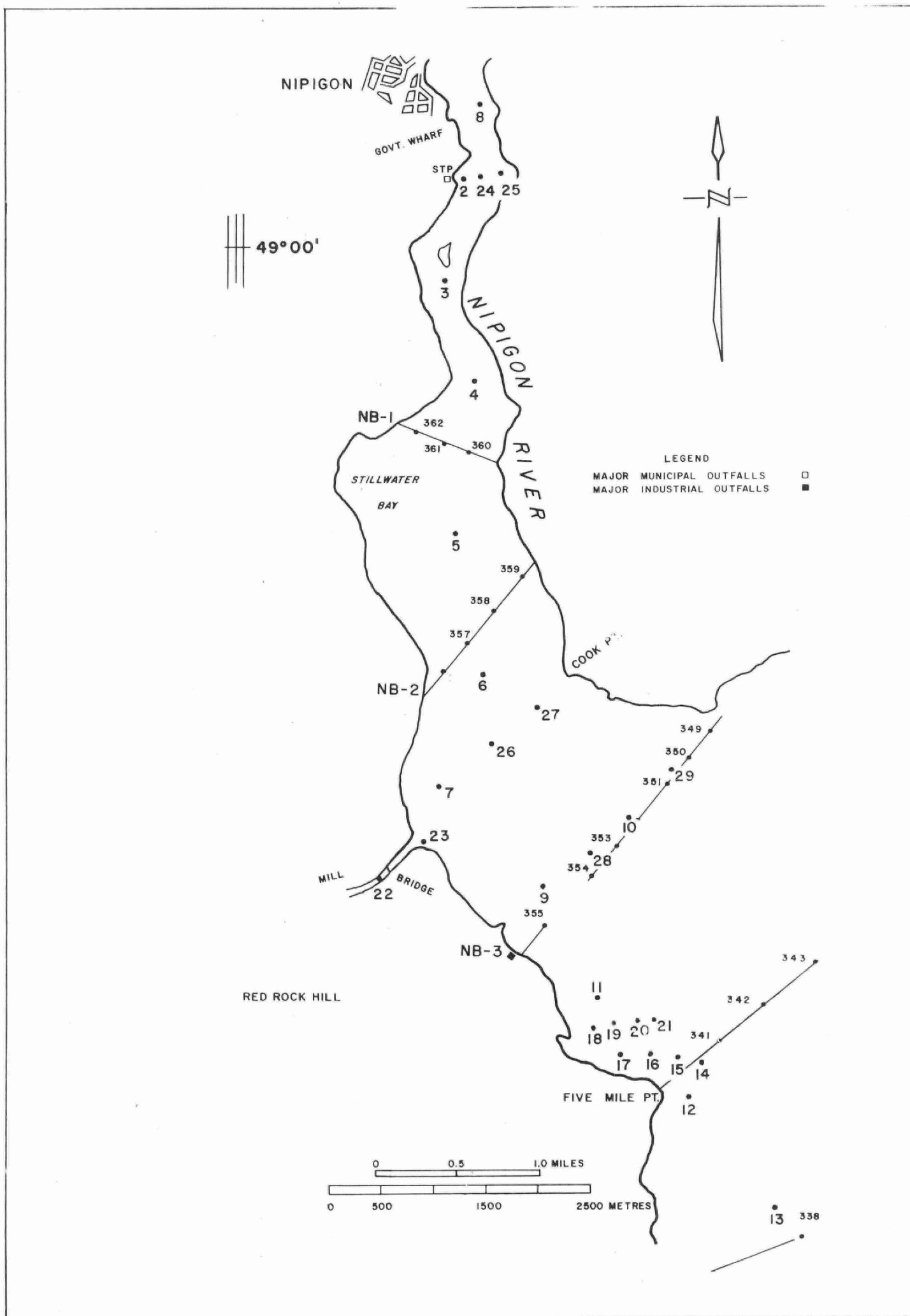


FIGURE 2 NIPIGON BAY SAMPLING STATIONS, 1974.

b) Statistical:

Water quality cannot be assessed accurately from a single sample because of changing environmental conditions. Therefore, a large number of samples were taken to satisfy these conditions. Statistical methods were used to summarize the results concisely and to reduce biased interpretation of the data. An analysis of variance program (ANOVA) was used to summarize the data. In this program, the calculated F ratio must be less than the critical F ratio (0.05 level) in order that stations compose a statistically similar group. If the F was significant, then those stations in the river with significantly different geometric means (GM) were deleted from the overall group to yield a group with similar means. Stations comprised a group provided that they were not separated by any geographic barrier, that the variances of all the stations were similar (Bartlett's χ^2 Test of Homogeneity) and that the data were normally distributed. Using the ANOVA program again, calculations were done on the deleted stations. This process was repeated until all possible groups were formed.

Results

1973:

Due to the great numbers of bacteria present, numerous filters were overgrown with colonies and in these cases only a minimal estimate of the bacterial density can be made. These results are indicated by a * in Table 1.

However, some idea of the extent of the pollution can be determined by noting that:

- a) by MOE criteria the water was unusable for any purpose at stations 1, 2, 3, 4, 5 and 7.

TABLE 1

1973

Station No.	Total Coliform/100 ml	FC/100 ml	FS/100 ml
1	15000 *	3000	2000
2	15000 *	3000	1900
3	15000 *	3000	2300
4	15000 *	3000	1300
5	4800	1240	780
6	330	100	50
7	1700	670	460
8	1300	200	150
9	90	10	10
10	10	10	10

* Actual concentration greater than reported

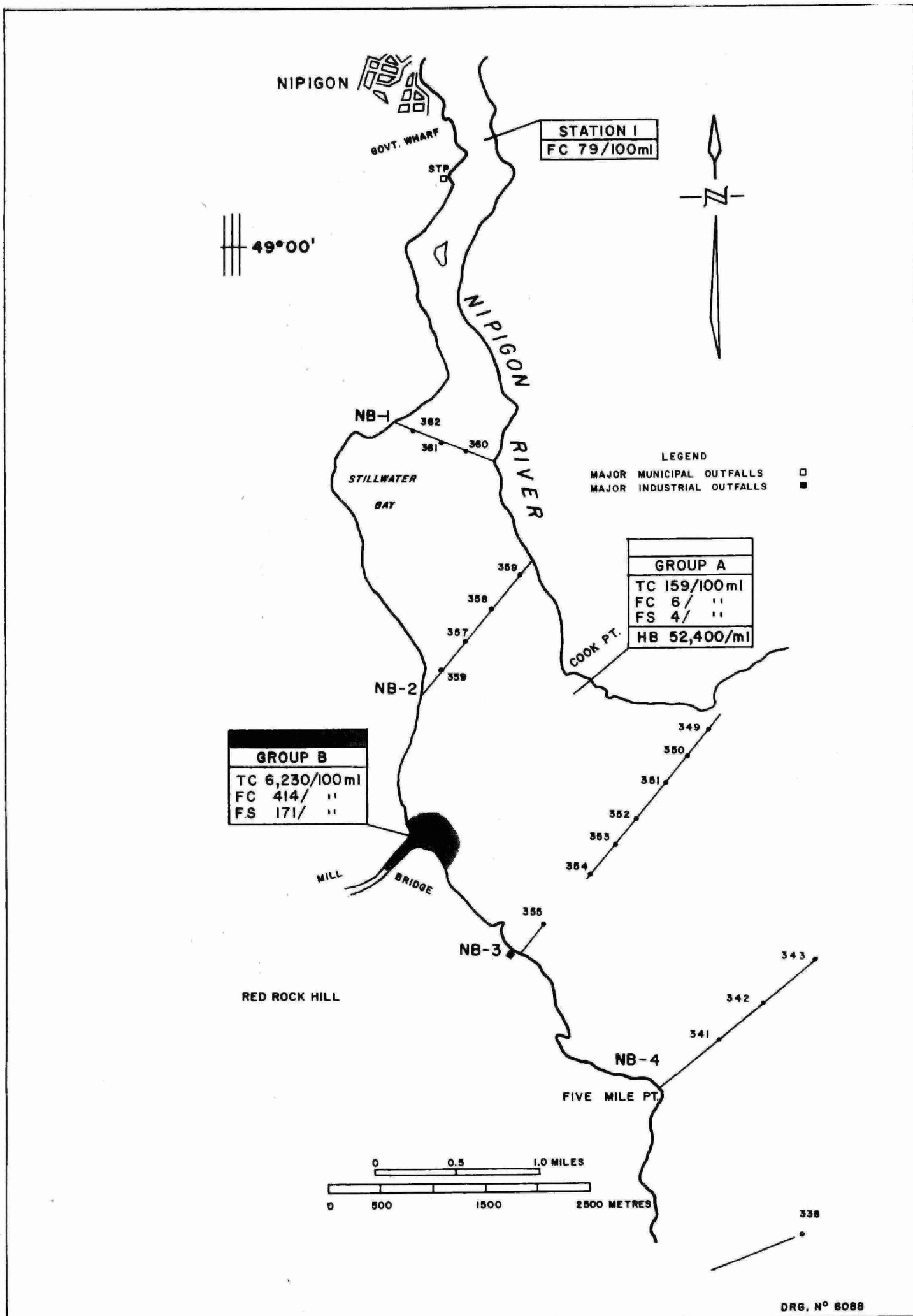
- b) water exceeded MOE criteria for Recreational Use and Private Water Use at stations 6 and 8.
- c) only two of the farthest south stations (Stations 9 and 10) were of acceptable water quality.

1974:

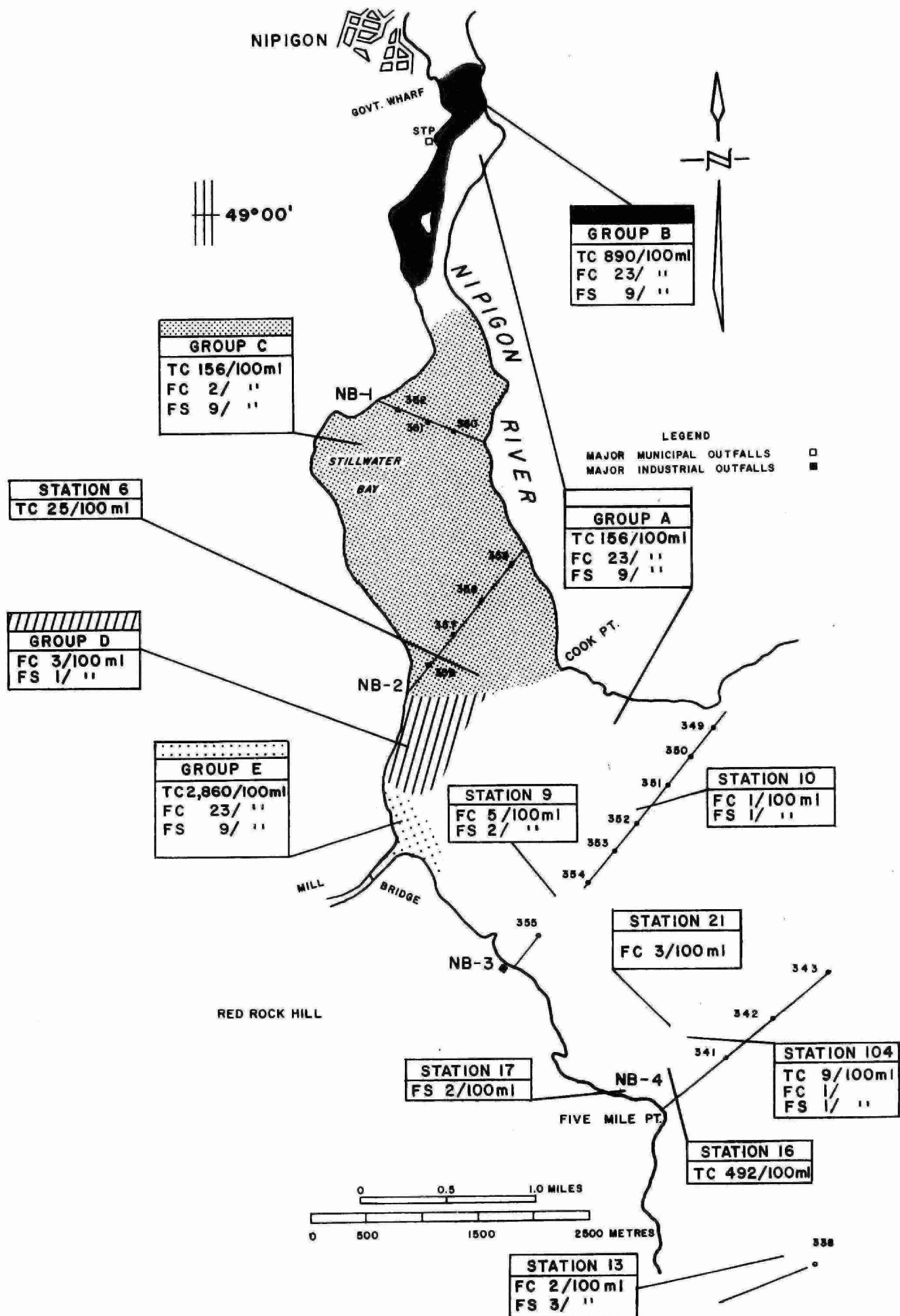
The majority of sampling points during the July 1-4 survey (Map 1) had TC, FC and FS densities of 159, 6 and 4/100 ml respectively (Group A). One area near Nipigon (Station 1) had a FC concentration of 79/100 ml which is approaching MOE Recreational Use Criteria. The FC:FS ratio here indicates human fecal waste as the source of contamination. Near the mouth of Trout Creek consistently higher densities of 6230 TC, 414 FC and 171 FS/100 ml (Group B) indicated very poor water quality. The TC and FS levels exceeded all MOE criteria while the FC exceeded Recreational and Private Water Use Criteria. The FC:FS ratio is intermediate indicating that pollution may come from both human and non-human sources. The HB density for the entire survey area was homogeneous at 52,400/ml (Group A). These densities would indicate much higher levels of organic nutrients in the area than other nearshore areas unaffected by pollution.

The majority of sampling points during the August 5-9 survey (Map 2, Group A) had TC, FC and FS concentrations of 156, 23 and 9/100 ml respectively. The area around Trout Creek close to the mill (Group E) again had higher TC levels (2860/100 ml), once more revealing serious water quality deterioration in this area. Downstream from Nipigon (Group B: 890 TC/100 ml), TC levels were close to the MOE criteria.

The HB population for most of the survey area was 80,800 HB/ml (Map 3, Group A), once again indicating high nutrient levels. The area around the Sewage Treatment Plant (STP) outfall (Group B) had a HB population of 2700/ml while the portion just northwest of Five Mile Point (Group C) had an extremely high population of 80,900 HB/ml. The mill area around Trout Creek (Station 23) had 47,800 HB/ml.

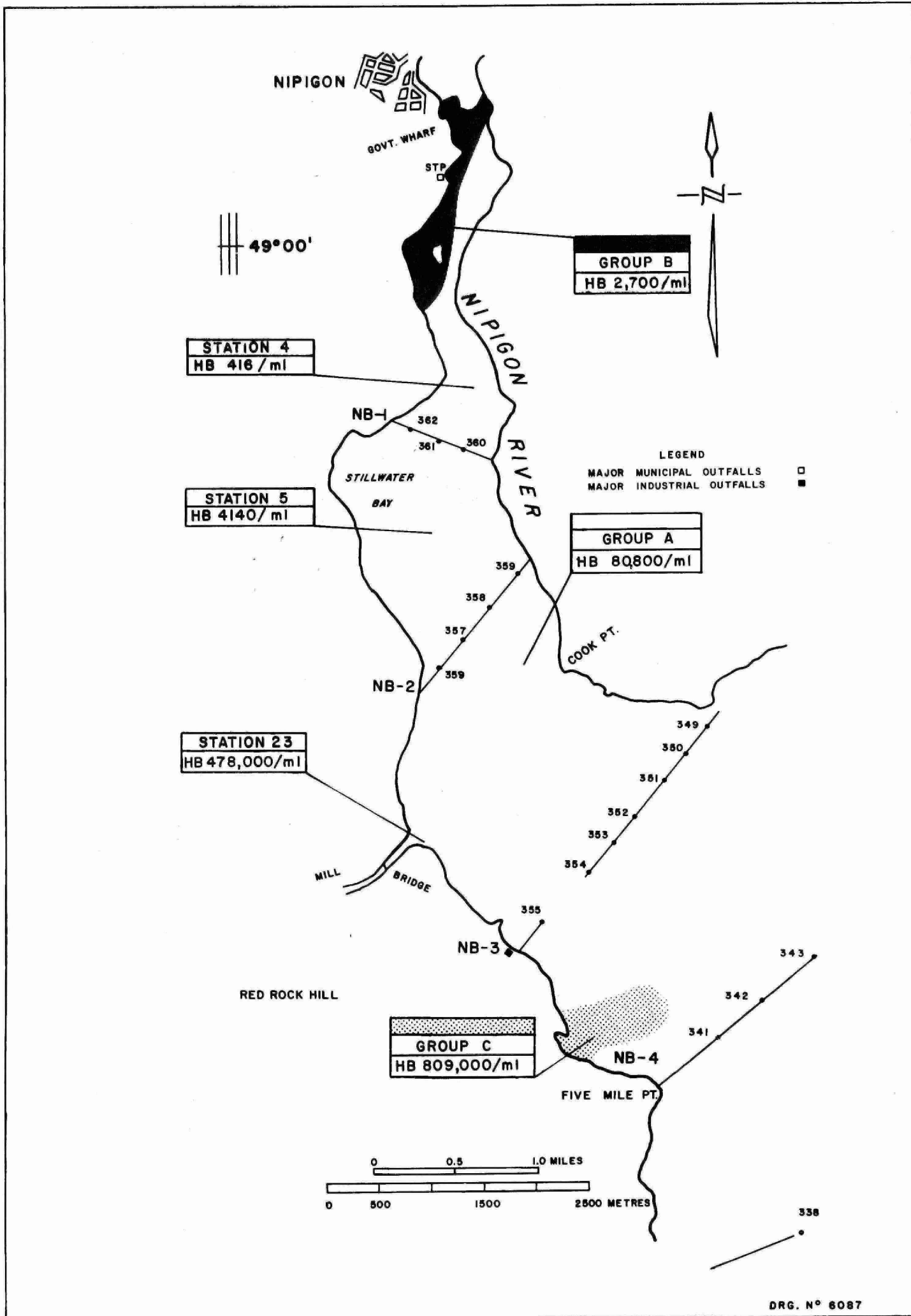


MAP I NIPIGON BAY — JULY 1-4, 1974.



DRG. N° 6084

MAP 2 NIPIGON BAY — AUGUST 5-9, 1974.



MAP 3 HETEROTROPHIC BACTERIA IN NIPIGON BAY, AUGUST 5-9, 1974.

Conclusions

The nearshore survey of Lake Superior indicated that bacterial levels rarely exceeded 300 TC, 10 FC and 20 FS/100 ml and generally in areas unaffected by point source inputs the levels for all parameters were $< 5/100$ ml. Therefore, it is possible to see from the survey results in Nipigon Bay that this area is severely affected by pollution. Inputs would appear to come from both Municipal and Industrial sources with Domtar Pulp & Paper being a major contributor.

FC:FS ratios tend to be intermediate indicating that at least part of the pollution is from improperly treated human fecal matter. Samples should be taken right at the actual point source inputs to determine what the true ratios are. They may in fact indicate a major input from human waste as this FC:FS ratio decreases with distance from source.

It is evident that the survey area (Nipigon Bay and River) is being grossly polluted and that the exact pollution inputs must be located and that corrective measures are required to prevent further deterioration of the area and enable water quality to be restored to an acceptable level.

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BACTERIOLOGICAL WATER QUALITY
OF JACKFISH BAY IN 1973

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MICROBIOLOGY SECTION
LABORATORY SERVICES BRANCH
MINISTRY OF THE ENVIRONMENT

FEBRUARY 1978

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ABSTRACT

Two sets of bacteriological samples were collected and analyzed 3 hours apart on July 16, 1973 from Moberly and Jackfish Bays. The results indicated greater water quality impairment in Moberly Bay than normally found in the more open waters of Jackfish Bay.

Area Description

Jackfish Bay, located approximately 150 miles from Thunder Bay, approximates 4 square miles and is divided into Moberly Bay and Tunnel Bay on the west and east sides respectively. Moberly Bay receives wastes via Blackbird Creek from the Kimberly-Clark Paper Company pulp mill at Terrace Bay while Tunnel Bay receives drainage from Jackfish Lake (Figure 1).

Objectives

A brief survey of the westerly arm of Jackfish Bay from the mouth of Blackbird Creek to the area just south of St. Patrick's Island was done on July 16, 1973 to determine the water quality at seven locations on the bay (Map 1) and to assess whether "significant changes have occurred since 1970" (1).

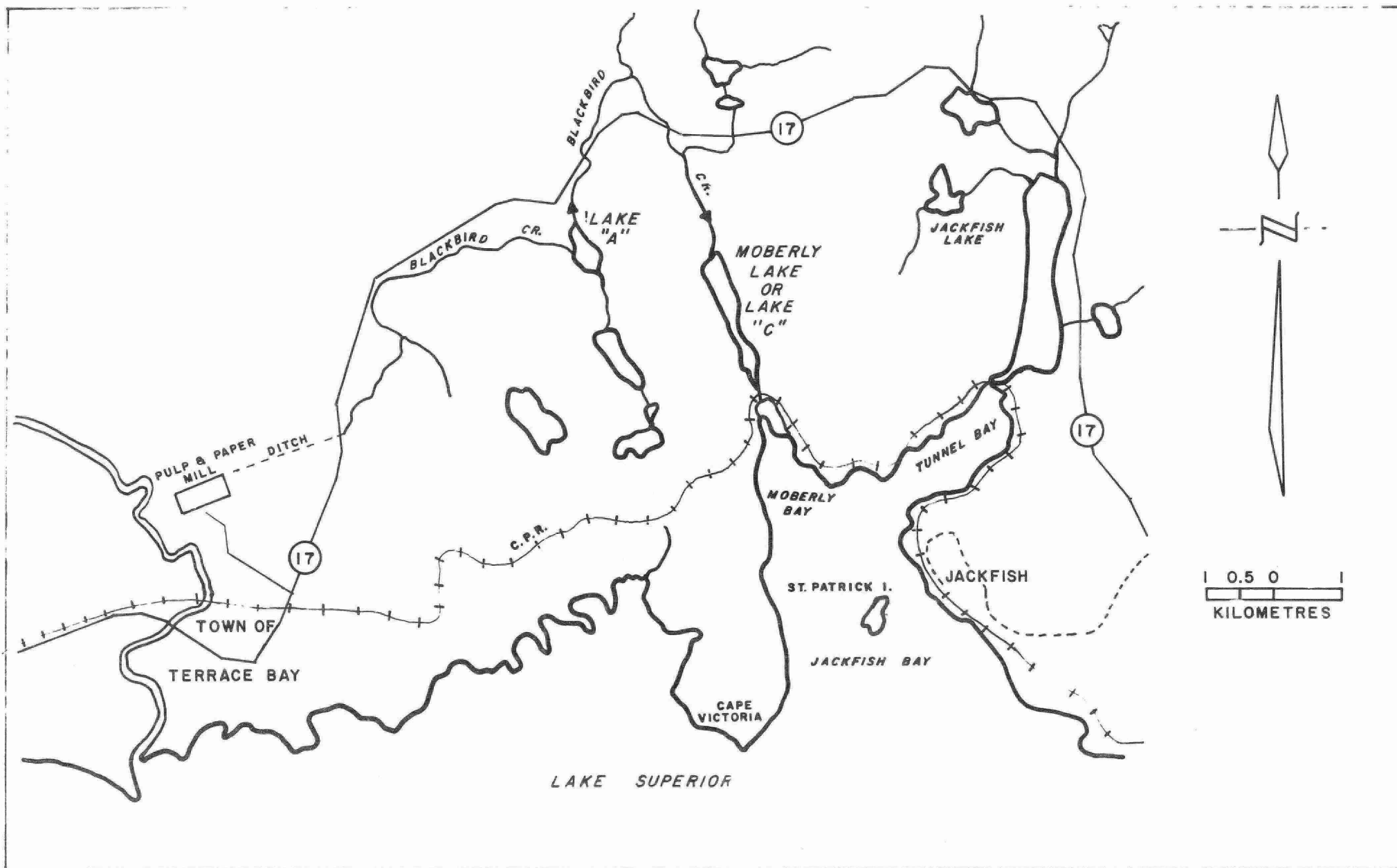
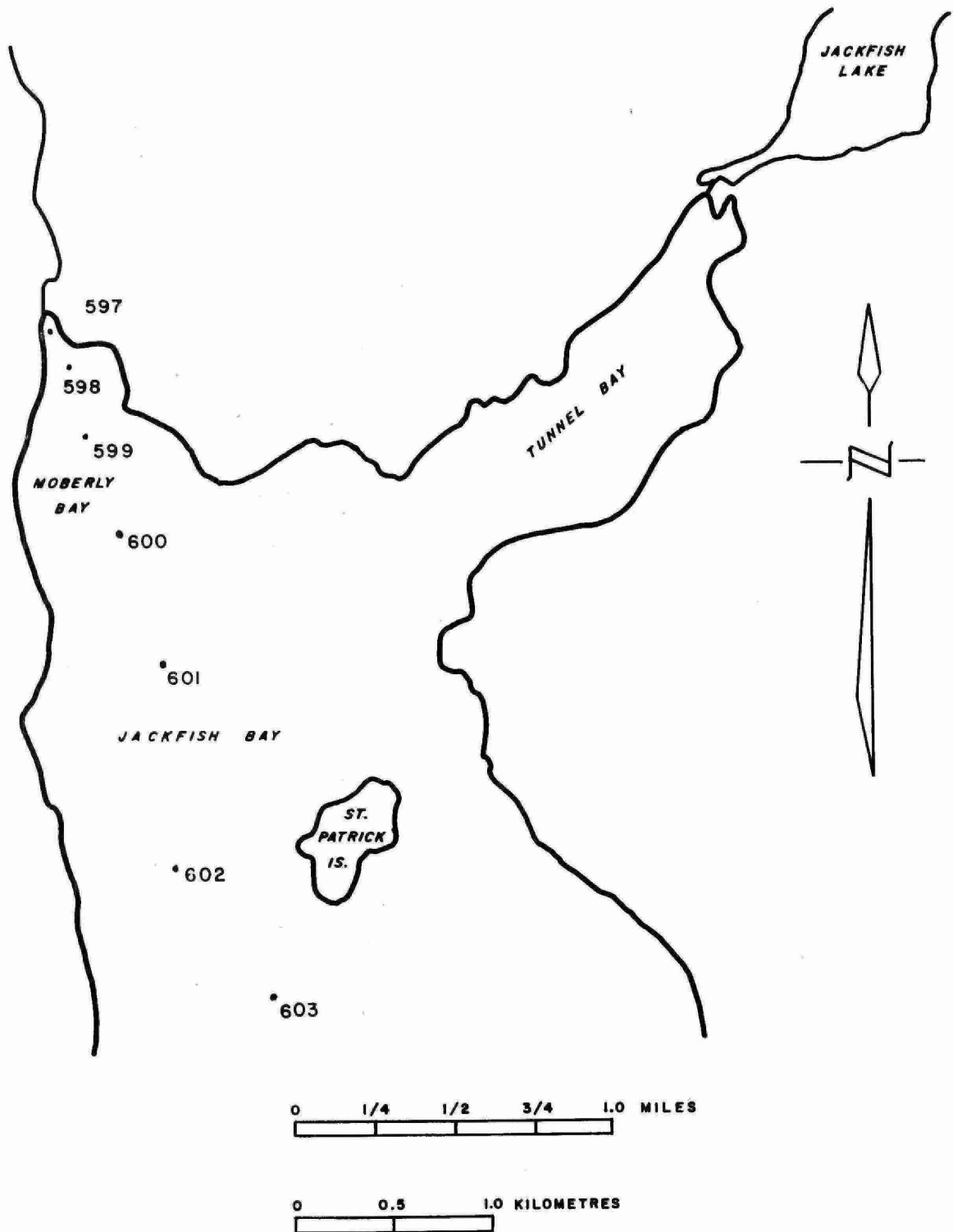


FIG. 1 STUDY AREA SHOWING BLACKBIRD CREEK AND JACKFISH BAY.



ORG N° 6093

MAP I JACKFISH BAY SAMPLING POINTS, 1973.

Methods

Two sets of samples were obtained approximately three hours apart. All bacteriological samples were sent for analysis to the mobile laboratory located in Thunder Bay. Samples were collected by means of sterile, 237 ml, evacuated rubber syringes and were stored on ice until they arrived at the mobile laboratory within 12 hours of sampling, at which time they were transferred aseptically to sterilized 250 ml polycarbonate bottles. Analysis for total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) using the membrane filtration technique (MF) as described in Standard Methods (2) were performed using m-Endo agar LES (Difco) for TC and MacConkey membrane broth (Oxoid) for FC determinations.

Criteria

The acceptable maximal bacterial levels for public raw water supplies are 5000 coliforms per 100 ml (TC/100 ml), 500 fecal streptococci (FS/100 ml) (3). Recreational Use waters are considered impaired when the TC geometric mean exceeds 1000 per 100 ml and/or the fecal coliform geometric mean exceeds 100 per 100 ml (3).

"Where the ratio of fecal coliforms to fecal streptococci (calculated from geometric means) exceeds 4.0, the source of bacterial contamination is likely to be human in origin. A ratio of less than 0.7 indicates an animal or storm water source of bacterial contamination" (4). This ratio must be used at or in the immediate vicinity of the source. In addition, it does not impart information of the safety of the water as animals can harbour human pathogens.

Results and Discussion

The very nature of the survey and type of data obtained invalidate the use of statistical analyses on the data for comparison with the Ministry of the Environment (MOE 1974) water quality criteria.

The July 16, 1973 results (Table 1) revealed higher TC levels just south of the Blackbird Creek inlet (Stations 597, 598, 599, 600) than those found in Jackfish Bay (Stations 601, 602, 603). FC levels were extremely high in Moberly Bay (Stations 599 and 600) during the second run, while the remaining area had levels of 1 FC/100 ml. On both surface and depth samples, FS densities fluctuated erratically between the two runs. The lack of data makes it impossible to properly identify sources or evaluate the degree of variability in bacterial levels. The results, however, indicated a trend of generally more serious water quality impairment towards Moberly Bay and Blackbird Creek.

Summary and Recommendations

1. Bacterial populations were highest at the mouth of the Blackbird Creek inlet to Moberly Bay with a general decrease in densities towards the open waters of Jackfish Bay. These trends closely approximate those of the 1970 survey. However, the insufficiency of the 1973 data invalidates any statistical comparison to the 1970 data.
2. The large variability and high counts during the 3 hours interval would indicate that Moberly Bay could be hazardous to recreational users should they be in this area.
3. The general deterioration of the environment around Moberly Bay restricts recreational activity to Tunnel Bay.

TABLE 1

SUMMARY FOR DATA FROM JACKFISH BAY JULY 16, 1973
(Counts per 100 ml)

Run No.	Station No.	TC	FC	FS
1	597	600 *	1	112
2	597	-	1	1
1	597 D	600 *	1	1
2	597 D	-	-	-
1	598	600 *	1	40
2	598	-	1	1
1	598 D	600 *	1	4
2	598 D	-	1	1
1	599	600 *	1	1
2	599	-	116	56
1	599 D	232	1	1
2	599 D	-	1	156
1	600	504	1	4
2	600	-	268	1
1	600 D	128	1	1
2	600 D	-	-	-
1	601	348	1	1
2	601	260	1	1
1	601 D	16	1	1
2	601 D	-	1	1
1	602	540	4	4
2	602	600 *	1	1
1	602 D	44	1	1
2	602 D	600 *	1	1
1	603	100	1	1
2	603	12	1	1
1	603 D	12	1	1
2	603 D	100	1	1

* Actual concentration greater than reported.

D Depth sample.

4. Improved methods of waste disposal should be adopted since the present system seems to be overloaded.
5. Both the lack of data and its variability indicate the need for a more intensive survey if more information is required in the future.

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BACTERIOLOGICAL WATER QUALITY
OF MARATHON PLUME IN
JULY AND OCTOBER 1973

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MICROBIOLOGY SECTION
LABORATORY SERVICES BRANCH
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FEBRUARY 1978

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Abstract

Bacteriological samples were collected and analyzed for two consecutive days in July and October 1973 in the effluent plume coming from the American Can Pulp & Paper Mill of Marathon.

The results were indicative of poorer water quality than normally found along the Lake Superior nearshore area and bacterial concentrations at times exceeded those set by MOE criteria.

It is suggested that further more intensive studies are necessary to properly elucidate the pollution problem in this area.

Introduction

Bacteriological samples were collected as part of the survey to determine water quality within the pulp and paper effluent plumes as they dispersed under varying wind conditions around "The Peninsula" near the Township of Marathon (Figure 1). The Peninsula extends approximately three-quarters of a mile in a northwesterly direction towards Lake Superior.

Most of the wastewater discharged into the lake emanates from the American Can of Canada Limited operation at Marathon and from the primary treatment plant serving the Township of Marathon. Water quality impairment varies in this area depending upon the extent and degree of dispersion and mixing of the mill and sewage treatment plant effluents with the waters of Lake Superior.

These effluents, which are influenced by wind direction and water currents, form a thin plume on top of the lake water due to the differential temperature gradient that exists between effluent and lake water.

Methods

Field Procedures:

The number of bacteriological samples collected from the plumes were as follows:

July 14/73	----	5
July 15/73	----	7
Oct. 30/73	----	10 *
Oct. 31/73	----	12 *

* Includes depth samples.

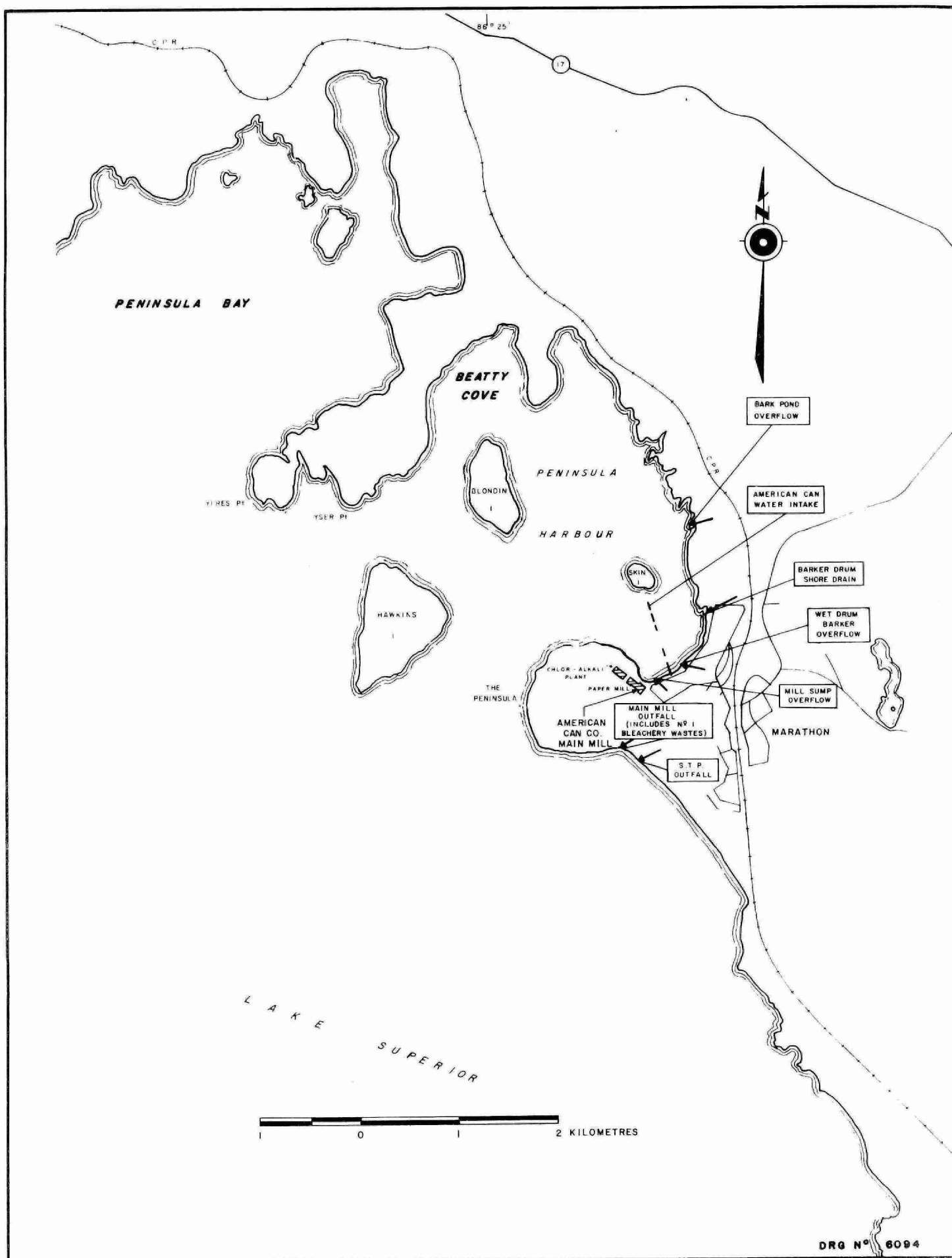


FIGURE 1 PENINSULA HARBOUR — LAKE SUPERIOR.

Depth samples were taken for each corresponding surface sample during the fall survey only. All samples were collected using a modified "piggyback" sampler and sterile 237 ml evacuated rubber syringes. Samples were stored on ice until they arrived at the mobile laboratory in Marathon during the summer surveys and at the Toronto laboratory during the fall surveys.

Lab Procedures:

All samples were transferred to sterile 250 ml polycarbonate bottles and analysis for total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) using the membrane filtration technique (MF) as described in Standard Methods 13th Ed. (1) were performed using m-Endo agar LES (Difco) for TC and MacConkey membrane broth (Oxoid), along with an incubation period of 18 hours, for FC determinations.

Criteria

With full treatment supplied, the permissible bacteriological water quality Ministry of the Environment (MOE 1974) criteria for public surface raw water supplies are maximum of 5000 coliforms per 100 ml (TC/100 ml), 500 fecal coliforms per 100 ml (FC/100 ml) and 50 fecal streptococcus per 100 ml (FS/100 ml) (2). Recreational Use waters are considered impaired when the TC geometric mean exceeds 1000 per 100 ml and the FC geometric mean exceeds 100 per 100 ml (2). The main use of FS is not so much in its actual concentration but rather in a ratio to fecal coliforms. "Where this ratio (FC/FS calculated from geometric means) exceeds 4.0, the source of bacterial contamination is likely to be human in origin. A ratio of less than 0.7 indicates an animal or storm water source of bacterial contamination" (3). This ratio must be used at, or very close to, the source of pollution. It can only be used to determine the source of pollution and not the safety of the water as animals can harbour human pathogens.

Results and Discussion

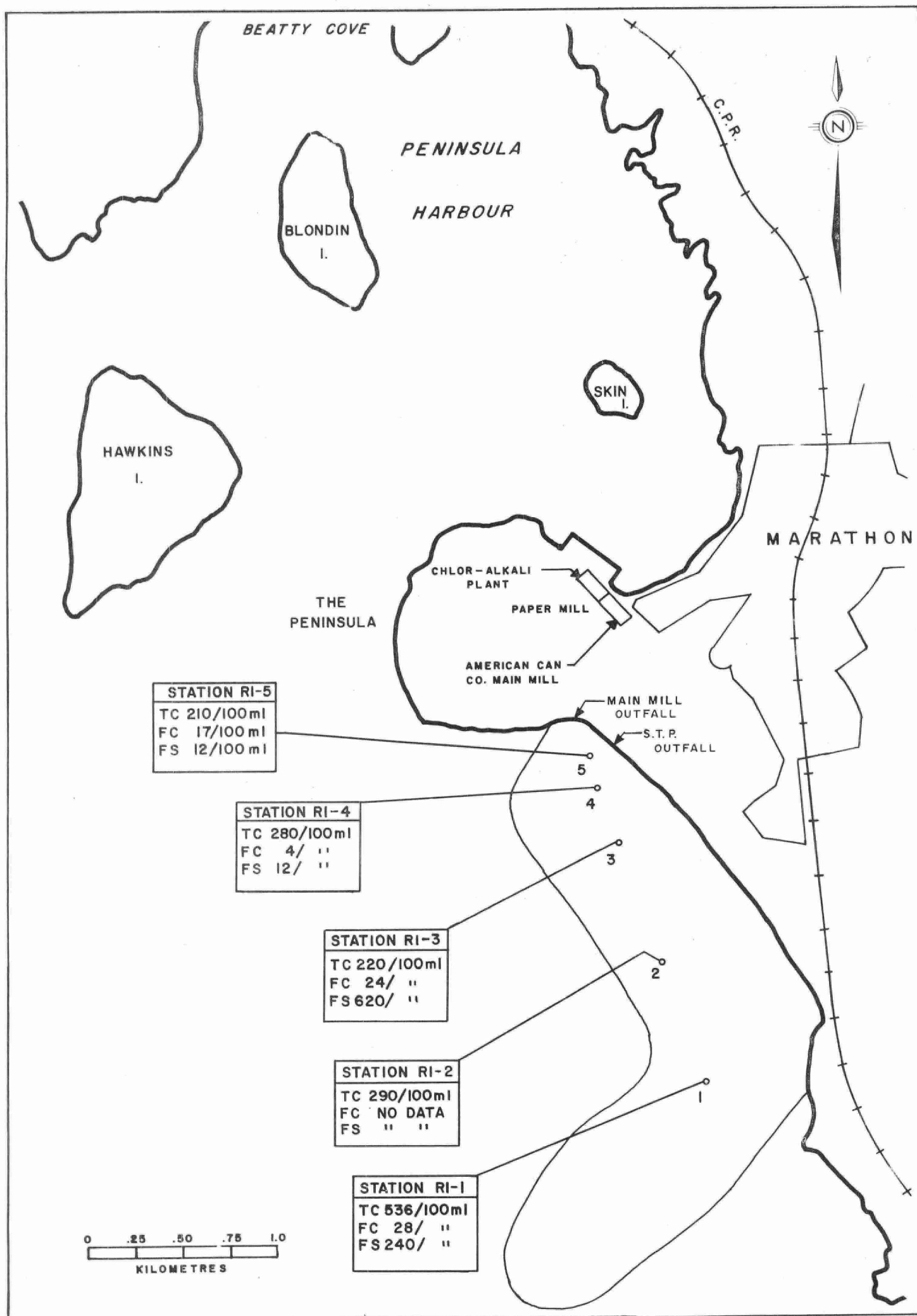
During the survey periods, insufficient samples were collected to warrant valid statistical comparisons to the above criteria. However, the individual counts per station relative to the criteria will, within limits, reflect the degree of water quality impairment in the plume areas. In addition, bacteriological densities can be compared to the nearshore sampling points along the Lake Superior coast within the vicinity of the Peninsula.

On July 14/73, the effluent plume lay immediately adjacent to the south side of the Peninsula (Map 1) while on July 15/73 the plume had shifted to a northwesterly direction around the tip of the Peninsula (Map 2). Bacterial concentrations on both days were higher than those found in unaffected nearshore waters (4). Thus water quality in the area is undoubtedly being adversely affected.

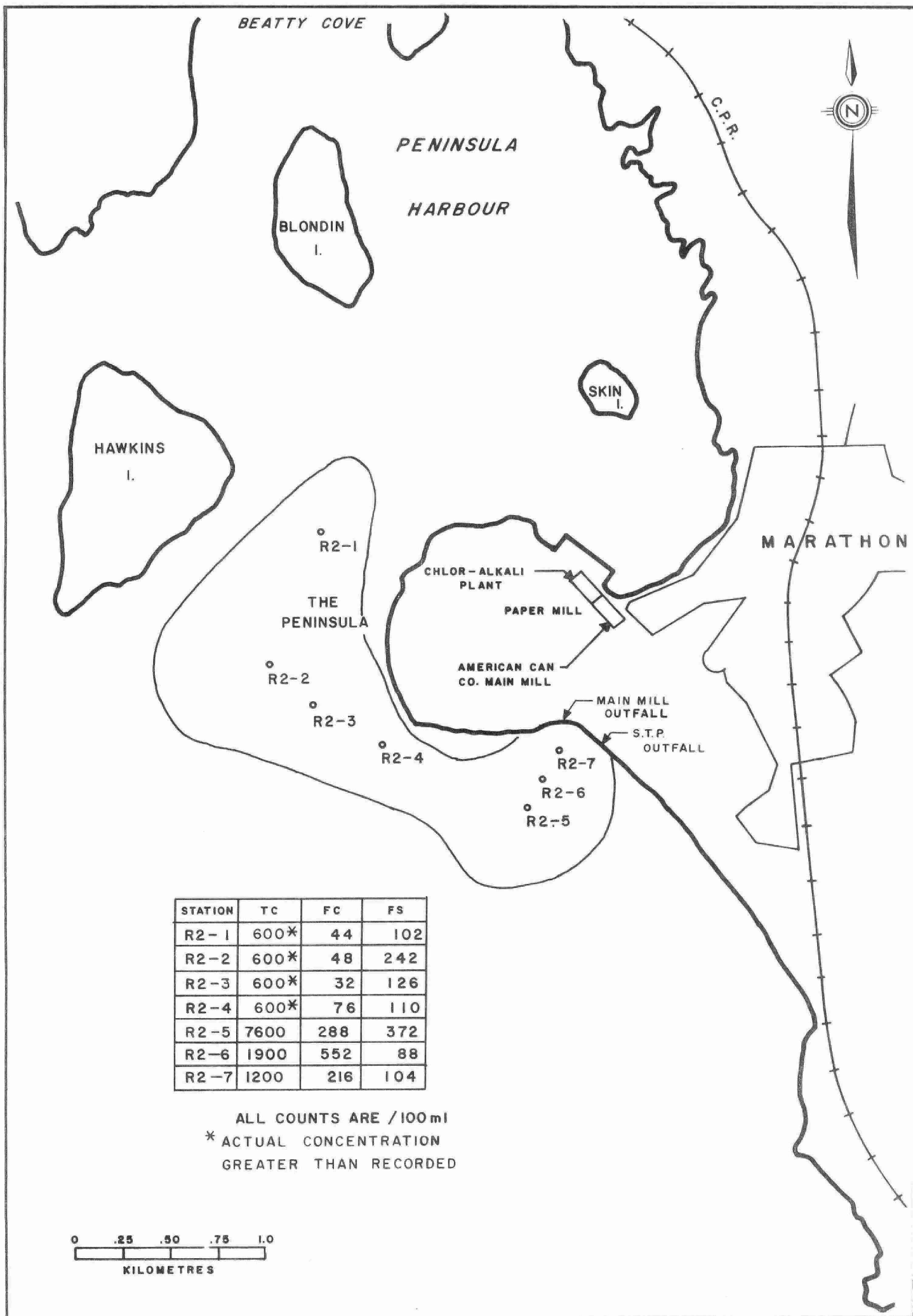
The densities of TC and FC in the July 15/73 plume area are greater than on July 14/73. However, on both days the relative levels of FC and FS at the stations closest to the outfalls would seem to indicate that contributions are being made both from human and non-human sources. The paucity of data, however, makes it impossible to properly identify the sources or evaluate the degree of variability in bacterial levels.

It is of interest to note that there appears to be a tendency for an increase in TC levels with increased distance from the outfalls. This may be caused by growth of the coliforms within the plume.

The October 30 and 31/73 effluent plumes were both located south of the Peninsula (Maps 3 and 4) with the October 31 plume being dispersed over a wider and more westerly direction. The data once again demonstrated great variability. On October 30/73, there was a tendency for surface stations to have lower TC, higher or the same FC, and higher FS concentrations than the depth stations. In addition, TC and FC levels were higher on October 30 than on October 31/73. On both days bacterial levels were higher than other unaffected nearshore waters (4).



MAP I MARATHON PLUME JULY 14, 1973.



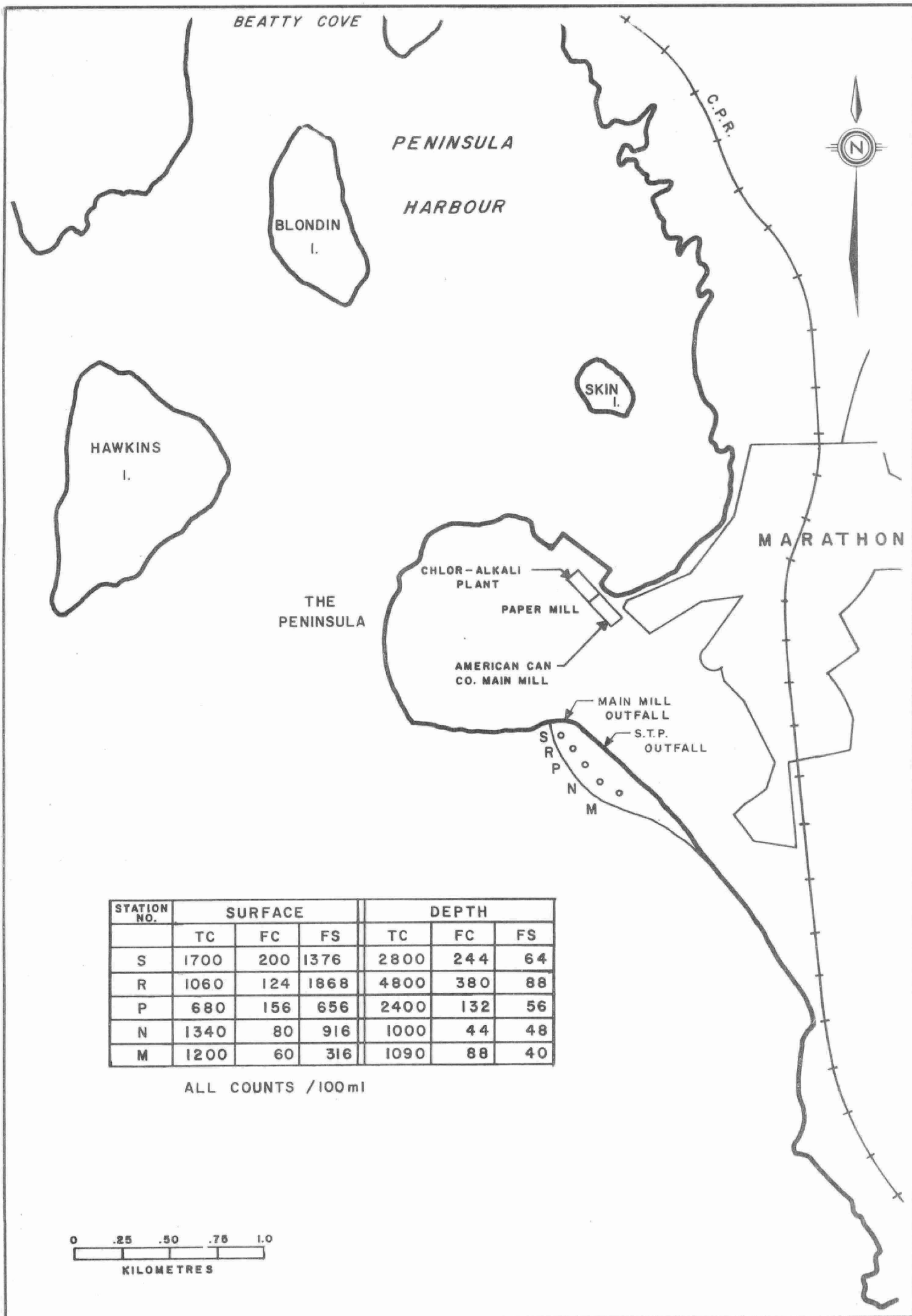
MAP2 MARATHON PLUME JULY 15, 1973.

The relative levels of FC and FS of stations closest to the source tended to indicate a non-human source, possibly the mill effluent, except for the depth stations S & R (Map 3) where FC was considerably higher than FS. The other depth stations on October 31 would indicate a combined input.

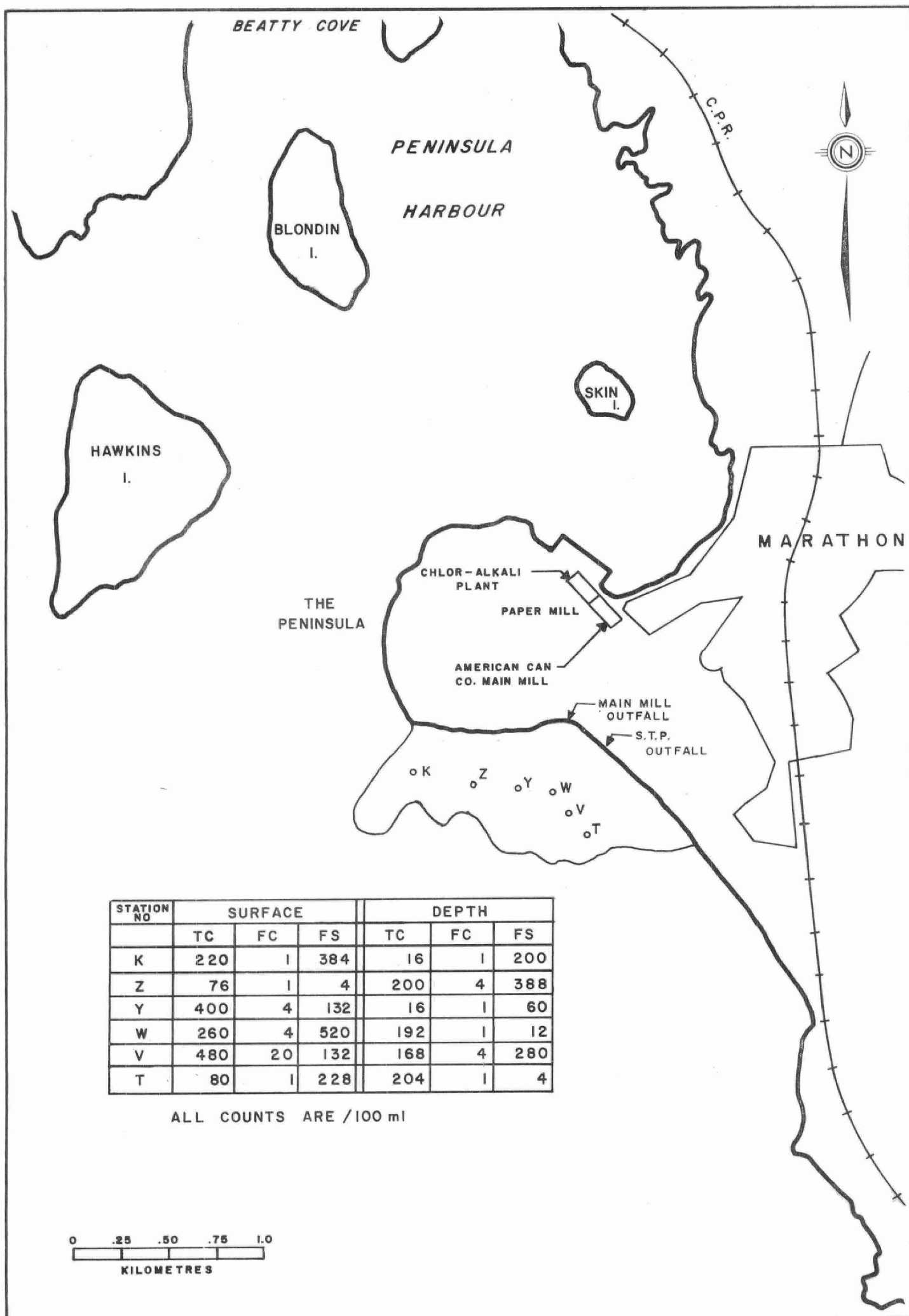
Once again, it would be necessary to obtain more data to properly assess the variability in bacterial densities and the FC:FS ratios.

Conclusions and Recommendations

1. The Bacterial Water Quality within the plume area is poor and is likely to effect adjacent nearshore waters. To prevent this treatment facilities should be constituted.
2. Data collected was not sufficient to fully assess the problem.
3. In any future survey, a more intensive sampling pattern should be employed which includes (a) outfall stations to obtain more information on the sources and (b) samples outside the plume area so the degree of impairment can better be assessed.



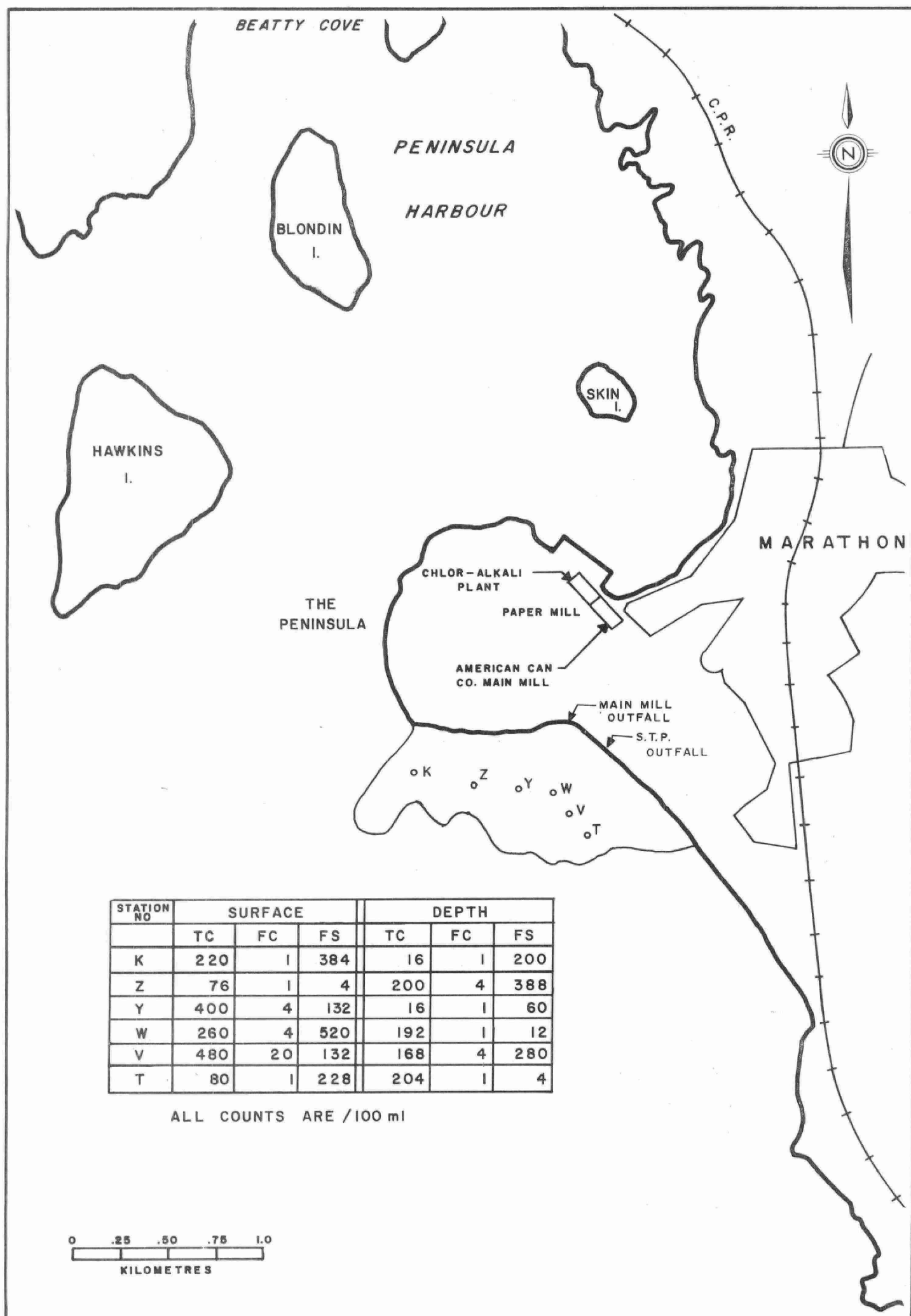
MAP 3 MARATHON PLUME OCT 30, 1973.



MAP 4 MARATHON PLUME, OCT 31, 1973.

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MAP 4 MARATHON PLUME, OCT 31, 1973.

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